The illusion of control: influencing factors and underlying psychological processes

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A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

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Declaration

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution to Anastasia Ejova and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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Acknowledgements

Einstein said that "if you can't explain something simply, you don't understand it". So many people contributed to this thesis becoming as simple as I could make it, but their selflessness in this is not something I can describe in a simple way or quite understand. I can only seek to emulate it in life's various projects, and having these examples to work with is an even greater gift than a completed degree.

My supervisors, Paul Delfabbro and Dan Navarro, bring attention to detail, publishing considerations, and a sense of humour to all their work, this thesis notwithstanding. I feel very lucky to have witnessed these tools being applied consistently over such a long period of time to create a simplicity I never thought possible. Apart from my supervisors' professionalism and humour, what stands out is their kindness. Paul gave me a great deal of conceptual freedom with this project and was then on hand with an arsenal of support for unexpected problems. Dan, meanwhile, was so generous with his time and head-space in lab-meeting discussions that we, his lab members, grew to love even topics not directly related to our theses.

In enumerating the many glorious aspects of the PhD experience that I cannot quite understand, I take the opportunity to acknowledge colleagues who answered calls for help in an unexpected level of detail. In particular, I would like to thank Magda Osman for being so prepared to bounce ideas across the equator; John Dunn for tuition in programming, maths, philosophy and what happens when they meet; David Lagnado and Tobi Gerstenberg for being the best lab visit hosts imaginable; Serguei Rassomakhine and Nancy Briggs for invaluable technical advice; Daniel King for working magic on the wording of some of my measures; Ted Nettelbeck for expert project management; and Alex Blaszczysnki and Keis Ohtsuka for, first, developing some very well-worded survey items and then helping me get access to them.

In the first year of candidature, a lovely friend presented me with a mug that bears inscriptions of Shakespeare's most famous adages about love. Two things relating to this mug leave me baffled: (a) was Shakespeare actually writing about his university friends, and (b) how did the mug survive thousands upon thousands of tea-time conversations? Dragana Calic, Anna Olshansky, Victoria Gilliland, Dinis Gokaydin, Adam Kane, Belinda Bruza, Drew Hendrickson, Simon DeDeyne, Adella

Bhaskara, Margaret Prysak, Emma Stewart, Angela Kinnell, Joanne Collins, Annemarie Monck, Jeremy Goldring, Heidi Long, Peter Chamberlain, Christopher Bean, Emmi Teng, Pat Alvaro, Kathleen Wright, Kaitlin Harkess, Natalie Matthews – I definitely can't compare them "to a summer's day" because I have had no use for such days in an underground office surrounded by marvellous people. Other sources of unforgettable conversation and help have been our administrative staff and the members of the Computational Cognitive Science Lab.

My sister, Maria, and our closest friends make up an ever-studying, ever-dancing, ever-travelling unit. In retrospect, how we managed these activities all at the same time is a bit of a mystery. It was probably thanks to Maria's clever use of my office as an art-dealership and restaurant, and to my darling office mate's, Rachel Stephens', very forgiving and welcoming attitude to all things, from the office buzz to thesis woes. Talk of dancing and travel was 'very effectively' combined with study during office visits by Diana Pham and Suzie Cosh. With Fernando Marmolejo-Ramos, we managed this even more effectively, with me typing away while watching him talk. Ertimiss Eshkevari's descriptions of the tea and ballet selection at Covent Garden made London a stopping point for many of us. Feeding the study-dance-and-travel troika were also the calming words and wild samba moves of Sarah Williams, Tuscan alfresco evenings with Cheryl Goult, and similarly multi-dimensional outings with Christian Gelinek, Ladan Sahafi, Kim Pfitzner and Tamara Hunyadi. I also thank the friends who have dedicated precious Skype time to thesis-strategising: Maria Montanes Gassol and family, Roger Forcada, and Nyla Sarwar.

Another thing impossible to describe simply is the support provided by my partner, Matt. Whatever is the equivalent of suspending all plans for two years to leave just a lot of gentleness and good sense for your partner to bask in – I owe him that in kisses.

Thanks also go to our families, who have always added the certainty of excitable conversation to our otherwise uncertain plans. My grandmother Nina in Russia has managed to do this from a great distance, while my grandmother Svetlana has complemented conversations with weekly gifts of strawberries because apparently they're good for the brain. I would like to dedicate this thesis to Vladimir Ejov and Julia Ejelovitch, my parents. I thank them, first and foremost, for having so many discussions about movies, books and human emotions, that my sister and I developed quite an obsession with well-turned arguments. When I turned this obsession into a potential career, my parents softened the initial failures that come with any career move by buying me thinking time and many pleasant distractions. The distractions included time at the family dinner table, which, thanks to them, is the most wonderful and surprising of destinations.

Statements of authorship

Paper 1: The illusion of control: structure, measurement and dependence on reinforcement frequency in the context of a laboratory gambling task

Published: Proceedings of the 9th Conference of the Australasian Society for Cognitive Science (2010)

Anastasia Ejova (Candidate)

The paper presents a subset of data collected as part of a larger study into influences on, and measurement of, the illusion of control. While my co-authors were involved in the design of the broader study, I was responsible for data collection and decisions on what data and arguments to present in this paper. I wrote a complete first draft and my co-authors subsequently assisted me with shortening the paper so that it met the publication's strict length requirements. I was later the corresponding author responsible for revisions to the paper based on the reviewer's comments.

Signed: .... Date: 03/04/13

Paul H. Delfabbro (Co-author)

I was the primary supervisor for the research programme that led to this paper, so was involved extensively in the design of the study described in the paper and discussions of results. Ms. Ejova was responsible for writing the paper, for which I then provided editorial comments and advice on making changes following review. I hereby give my permission for this paper to be included in Ms. Ejova's submission for the degree of PhD at the University of Adelaide.

Signed: .... Date: 03/04/13

Daniel J. Navarro (Co-author)

As the co-supervisor of Ms. Ejova's PhD research programme, I was involved in discussions of the results and suggested that she write up some portion of them as a submission to this conference. Ms. Ejova was responsible for writing the paper, and I then explained in detail how some sections could be written more concisely to meet the requirements of shorter publications of this kind. I also offered advice on how to respond to reviews, in terms of both revising the paper's content and composing a response letter. I hereby give my permission for this paper to be included in Ms. Ejova's submission for the degree of PhD at the University of Adelaide.

Signed: .... Date: 04/04/13

Paper 2: Success-slope effects on the illusion of control and on remembered success-frequency

Submitted for publication

Anastasia Ejova (Candidate)

I was responsible for study design, data collection and analysis, and the development of the article's ideas through conference presentations and discussions with my co-authors. I also wrote the paper, with each section being carefully edited by my co-authors. I have revised the paper twice in response to reviews and have, with help from Dr. Navarro, conducted correspondence regarding both sets of revisions.

Signed: .... Date: 03/04/13

Daniel J. Navarro (Co-author)

The paper is targeted at a journal specialising in judgement and decision-making, and, given my experience in publishing in this field, I offered extensive guidance to Ms. Ejova about how to structure and shorten sections of the paper. Prior to the second submission, I also edited the paper as a whole and helped Ms. Ejova draft letters to the action editor. I have also made comments on data analysis changes recommended by reviewers. Ms. Ejova was responsible for writing the paper and I hereby give my permission for this paper to be included in Ms. Ejova's submission for the degree of PhD at the University of Adelaide.

Signed: .... Date: 04/04/13

Paul H. Delfabbro (Co-author)

I was involved in discussions of study design and results, and edited numerous drafts of the paper. I focused, in particular, on the structure of the Introduction, and the presentation of results. Ms. Ejova was responsible for writing the paper and I hereby give my permission for this paper to be included in Ms. Ejova's submission for the degree of PhD at the University of Adelaide.

Signed: .... Date: 03/04/13.

Paper 3: Erroneous gambling-related beliefs as illusions of primary and secondary control: a confirmatory factor analysis

Submitted for publication

Anastasia Ejova (Candidate)

I conceived of the study design in consultation with my co-authors and collected the data. Data analysis involved fitting a model, the qualitative details of which I also discussed at length with my co-authors. My co-authors also offered advice on common practices for fitting models through confirmatory factor analysis. I wrote a full draft of the paper before Dr. Delfabbro and I engaged in a series of edits and discussions in order to make the qualitative details of the model understandable to gambling researchers – the readership of the journal where the paper is currently under review.

Signed: .... Date: 03/04/13

Paul H. Delfabbro (Co-author)

As the study was being designed, I offered extensive advice on what items should be included in the survey analysed in this paper. With respect to data collection, I advised Ms. Ejova on best practices in conducting survey studies in the general community. With my experience in confirmatory factor analysis, I also provided technical support during data analysis. After the analyses were written up in a draft of the paper, I provided extensive editorial comments on what additional gambling-related literature needed to be mentioned to justify the modelling decisions. Ms. Ejova was responsible for writing the paper and I hereby give my permission for this paper to be included in Ms. Ejova's submission for the degree of PhD at the University of Adelaide.

Signed: .... Date: 03/04/13

Daniel J. Navarro (Co-author)

I was involved in early discussions of study design and, like Dr. Delfabbro, answered numerous technical questions regarding confirmatory factor analysis. I also offered suggestions about how to structure the paper's Introduction before Ms. Ejova began writing the paper. Ms. Ejova was responsible for writing the paper and I hereby give my permission for this paper to be included in Ms. Ejova's submission for the degree of PhD at the University of Adelaide.

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Abstract

The illusion of control refers to the overestimation of the probability of a win following a personal action in a gambling game. This thesis identifies gaps in the body of literature on factors influencing the illusion, uses a theoretically motivated methodology to address them, and tests the theory underlying the methodology.

The thesis consists of a literature review and three papers. The review focuses on factors found to influence the illusion – factors such as the number of response options available in the gambling task, the degree of need for money, the average frequency of successes/wins in a sequence of rounds, and success-slope (i.e., whether wins are concentrated at the beginning or end of the sequence). The review draws attention to problems with the way the illusion of control has been measured in studies of success-frequency and success-slope. This observation, in turn, raises questions as to whether success-frequency and success-slope are, indeed, factors that influence the illusion.

The review goes on to discuss the psychological processes underlying the effects of various influencing factors. Two relatively unexplored arguments are advanced. The first is that people in gambling tasks engage in problem-solving. Problem-solving involves searching for actions that bring about the desired outcome, which, in gambling settings, is a substantial monetary win. The greater the number of available response options and the need for money, the more likely the player is to still be searching for effective actions at the time that her perceived control is measured. Such a player is, in turn, less likely to report having 'no control' over the task. A second and related argument is that the actions people consider during problem-solving are influenced by their beliefs about the task at hand. In gambling, beliefs in the gambler's fallacy (Oskarsson et al., 2009) and beliefs about supernatural agents such as luck and God (Atran & Norenzayan, 2004) are particularly relevant. In line with terminology used by Rothbaum, Weisz and Snyder (1982), it is proposed that the illusion of control has two variants, primary and secondary, influenced by the gambler's fallacy and beliefs in supernatural agents respectively.

The first two papers describe re-examinations of the effects of success-frequency (N = 97) and success-slope (N = 334) using a methodology consistent with

the above explanation. Like most studies of these two factors, the experiments involved a gambling session under a particular success-frequency or success-slope condition, followed by a post-experimental questionnaire about the degree of perceived control over task outcomes. The novel aspects of the methodology included, for example, the separate measurement of the illusion's two variants. Success-frequency was found not to influence the illusion of control when it was measured in this way, while the influence of success-slope was confirmed, in that an 'ascending slope' (a concentration of wins at the end of the sequence) was found to be associated with higher illusory primary control. The finding regarding success-slopes suggests that people expected to learn the correct way of playing through trial-and-error, which is consistent with the above argument that people engage in problem-solving when gambling.

The third paper describes a confirmatory factor analysis of a survey about erroneous gambling-related beliefs (N = 329). Items were based on interviews with people who gamble regularly, and, therefore, represented illusions of control – problem-solving solutions based on some playing experience. Consistently with the second argument presented above, the factor analysis showed that the items could be described in terms of two latent factors reflecting the gambler's fallacy and beliefs about supernatural agents, respectively.

CHAPTER 1: Introduction and literature review

Games of pure chance, by definition, involve no causal contingency between actions and the desired outcome; that is, they do not allow for personal control (e.g., Jenkins & Ward, 1965). In light of this, the behaviour Langer (1975) documented in some early studies of lotteries did not appear rational. Lottery participants behaved and answered post-task questions as though they perceived some personal control over the lottery's outcome. In one study, participants who chose their ticket nominated a re-sale price higher than that nominated by participants who were simply given a ticket by the experimenter. This suggested that participants believed there to be a causal relationship between their choice of ticket and the lottery's outcome. In another study, participants whose tickets were labelled with a letter as opposed to a technical symbol were more reluctant to trade their ticket for a ticket in a lottery with better odds. This suggested that participants were acting as they would in a skilled game, developing more strategies when stimuli were familiar and therefore perceiving more control in those circumstances. In a third study, participants who spent more time thinking about the lottery as a result of receiving their ticket number one digit at a time over the course of three days expressed greater confidence of winning than participants who were immediately notified of their three-digit ticket number. This finding again suggested that participants were strategising as they would in a skilled game, developing more strategies when more time for thinking about possible strategies was available.

Langer labelled action-outcome contingency perceptions in games of chance an illusion of control and interpreted her findings as evidence that the illusion arises because games of chance possesses features of skilled tasks. Skilled-task features include the factors found to influence the illusion in Langer's experiments: opportunity for choice, familiar stimuli, and greater time for thinking about possible actions and outcomes. According to Langer, skilled-task features in games of chance signal to players that they should act as they would in a skilled task. This means "engaging in overt and covert behaviours to maximise the probability of success: [behaviours such as] thinking about the task to arrive at possible strategies that may be employed" (p. 313). The more skilled-task features a game of chance possesses, the more likely it is to be confused for a skilled task and give rise to strategising.

Subsequent research on the illusion of control has sought to replicate Langer's findings and show that the effects she observed generalise to a variety of gambling tasks (e.g., roulette and slot machines). Most of these studies confirmed Langer's findings. Studies have also sought to identify other factors influencing the illusion of control. Frequently-investigated factors not originally examined by Langer include success (i.e., win) frequency, and success-slope, which refers to whether wins are concentrated at the beginning or end of a gambling session with multiple trials.

A problem with the body of literature on factors influencing the illusion relates to the psychological explanation of the effects. Although numerous explanations have been advanced, none have been entirely successful in accounting for the results observed across the majority of studies. Langer's explanation above is an example. It proposes that choice, stimulus familiarity and thinking time are influential because they are characteristics of skilled tasks and therefore encourage strategising in games of chance. However, the extent to which this explanation accounts for the effects of choice and other skilled-task features in lottery tasks is questionable. When a slot machine game is imbued with additional choices (e.g., a lever for stopping the spinning reels), it is feasible to propose that participants might attempt to look for a way exert influence over the outcomes (e.g., Ladouceur & Sevigny, 2005). However, the simple lottery tasks in Langer's experiments did not allow for the same range of different responses as a slot machine, even when opportunities for choice, familiar stimuli, and increased thinking time were introduced. Further explanation is, therefore, needed of why participants in Langer's lottery studies did not consider all possible responses and quickly come to the conclusion that no particular response could improve their chances of winning.

A central aim of this thesis is to propose a more comprehensive explanation of the psychological processes underlying the illusion of control and causing it to be influenced by certain factors (choice, stimulus familiarity, etc.) in a variety of gambling tasks. This first chapter provides a review of the literature on influencing factors (Section 1), describes the sense in which existing explanations of underlying psychological processes have failed to account for some relevant studies (Section 2), and outlines the explanation that forms the basis for this project (Section 3).

The thesis has the further aim of addressing problems with the methods used in identifying success-frequency and success-slope as influences on the illusion. The problems are described in Section 1, with Section 4 then describing specific research questions motivated by these problems and the presented explanation of psychological mechanisms underlying the illusion. The subset of questions pursued in the current project is specified in a final section.

1. Influences on the illusion of control

Studies of influences on the illusion of control have typically used experimental tasks involving randomly generated outcomes. Following one or more trials of the task under a condition where a hypothesised influence is absent or present (e.g., choice vs. no choice), the degree of the illusion of control is inferred based on behavioural or self-report measures. The opening of the chapter described three of the five influences investigated by Langer. This section will describe research on all five influences, as well as research on influences investigated by other authors. All the contributing studies are listed in Table 1.1.

1.1. Opportunity for choice and physical involvement

Langer's experiment on the effects of opportunity for choice was described at the start of this chapter. Half the participants in an office lottery chose their tickets, while the other half were simply given tickets by the experimenter. On the morning of the drawing, participants were asked to name the price for which they would be willing to re-sell their ticket to a latecomer. Those in the choice condition demanded an average of $8.67 – over four times the $1.96 quoted by participants in the no-choice condition. Langer replicated the result in another office lottery (Langer, 1975, Experiment 3), where participants who chose their tickets were found to be more reluctant to exchange their ticket for one in a lottery with better odds.

Since opportunity for choice is difficult to disentangle from degree of physical involvement (degree of physical contact with aspects of the task), most replications of Langer's 'choice' finding have tended to combine the two factors (see Table 1.1). Originally, however, Langer (1975, Experiment 4), examined the effects of physical involvement separately. At the centre of the task was a never-before-seen apparatus with three electronic paths. The participants were informed that, on each trial, the machine randomly selected a winning path, following which activated a buzzer. The participants' task was to guess which path was the winning one, and the stylus was then moved to determine whether they were correct. In the 'no involvement' condition, the experimenter and not the participant moved the stylus. Physically involved participants exhibited higher pre-trial confidence that they had selected the winning path, and, after a single successful trial, rated themselves higher on a scale where 1 indicated that they were much worse on the task than a champion chess player and 10 indicated that they were much better.

The effects of choice and physical involvement have been replicated in a variety of gambling tasks. For example, Ladouceur and Mayrand (1987) investigated the effects of physical involvement in a roulette task. Over 40 trials, participants in the 'involvement' group personally threw a ball onto the roulette wheel after betting on a colour or number. For those in the 'no involvement' group, the bet was still chosen by the participant, but it was the experimenter who threw the ball onto the wheel. The involvement group tended to bet more on riskier options (e.g., a single number), which suggested that they were more confident of winning.

1.2. Stimulus familiarity

Also briefly described in the opening of this chapter was Langer's experiment on the effects of stimulus familiarity. Lottery participants whose tickets were labelled with a letter as opposed to an unknown symbol displayed a greater reluctance to trade their ticket for one with better chances of winning. A replication of the effect followed (Bouts & Van Avermaet, 1992). Participants played a card game round against the experimenter, betting on whether the card they selected from a deck would be higher. Bet amounts were lower when the deck contained cards of an unconventional length-to-width ratio and with Egyptian symbols rather than patterns inscribed on the back.

These findings do not necessarily suggest that the illusion of control is strengthened when stimuli are familiar. The effect being observed could also be one of the suspicion associated with *un*familiarity. That is, playing familiar games (lotteries, cards) with odd stimuli might have made participants suspicious about whether the games were really fair. Such suspicion could have, in turn, lowered perceived control.

Table 1.1. Studies identifying influences on the illusion of control

Influencing factor	Associated studies
Choice	Langer, 1975, Expts 2 and 3 Gilovich & Douglas,1986
Physical involvement	Langer,1975, Expt 4 Wortman, 1975 Ladouceur & Mayrand, 1987 Fleming & Darley, 1990
Choice and physical involvement	Ayeroff & Abelson, 1976 Benassi, Sweeney & Drevno, 1979 Ladouceur et al., 1984 $^{--}$ Koehler, Gibbs & Hoggarth, 1994 Budescu & Bruderman, 1995 Dixon, 2000 Wohl & Enzle, 2002 Ladouceur & Sevigny, 2005
Stimulus familiarity	Langer, 1975, Expt 3 Bouts & Van Avermaet, 1992
Decision time	Langer, 1975, Expts 5 and 6
Opportunity for practice	Langer, 1975, Expt 4 Ayeroff & Abelson, 1976 Benassi, Sweeney & Dreveno, 1979
Success-slope	Langer & Roth, 1975 Ladouceur & Mayrand, 1984 Burger, 1986 Matute, 1995 Coventry & Norman, 1998
Opportunity for competition	Langer, 1975, Expt 1 Budescu & Bruderman, 1995 $^{--}$ Rudski, 2001 $^{--}$
Success-frequency	Jenkins & Ward, 1965 Alloy & Abramson, 1979 Tennen & Sharp, 1983 Benassi & Mahler, 1985 Letarte, Ladouceur & Mayrand, 1986 Vasquez, 1987 Mikulincer, Gerber & Weisenberg, 1990 Rudski, Lischner & Albert, 1999 Thompson et al., 2004, 2007 Blanco, Matute & Vadillo, 2011

Influencing factor (cont.)	Associated studies (cont.)
Need for the outcome	Friedland, Kienan & Regev, 1992
	Biner et al., 1995
	Biner, Huffman, Curran & Long, 1998
	Thompson et al., 2004
	Biner, Johnston, Summers & Chudzynski, 2009
	Gino, Sharek & Moore, 2011
Strength of belief in luck	Wohl & Enzle, 2002
	Wohl & Enzle, 2009
Foreknowledge	Strickland, Lewicki & Katz, 1966
	Wortman, 1975
	Ladouceur & Mayrand, 1987
Locus of control	Strickland, Lewicki & Katz, 1966
	Benassi, Sweeney & Drevno, 1979 [--]
	Tennen & Sharp, 1983 [--]
	Hong & Chiu 1988
	Rudski, Lischner & Albert, 1999
Desirability of control	Burger & Cooper, 1979
	Burger & Schnerring, 1982
	Wolfgang, Zenker & Viscusi, 1984 [--]
	Burger, 1986
Depression	Alloy & Abramson, 1979
	Tennen & Sharp, 1983
	Benassi & Mahler, 1985
	Vasquez, 1987
	Mikulincer, Gerber & Weisenberg, 1990
	Blanco, Matute & Vadillo, 2009
Anxiety	Friedland, Kienan & Regev, 1992

[--] No effect

1.3. Thinking time

The length of time spent thinking about actions and outcomes within a task was examined by Langer (1975, Experiments 5 and 6) but not in any subsequent studies. In one of Langer's studies, participants in the 'longer thinking time' group were given their three-figure lottery numbers at a rate of one per day, rather than all at once, as in the control group. Confidence in winning (on a 10-point analogue scale) and reluctance to trade tickets for a lottery with better odds were higher in this group.

1.4. Opportunity for practice

Another skilled-task feature identified by Langer as an influence on the illusion of control is opportunity for practice. In the same experiment that investigated the effects of physical involvement, Langer manipulated whether or not participants had two minutes to inspect the path apparatus and practice moving the stylus. Pre-trial confidence ratings and ratings of competence relative to a chess player were higher among the more practiced participants.

The effects of practice were later replicated in two studies involving psychokinesis tasks. One study (Benassi, Sweeney & Drevno, 1979), for example, involved a machine that electronically released a die. The die had three red sides and three green sides. Participants were asked to choose a colour and concentrate on it coming up for 20 trials. Those who practiced for 10 trials as opposed to one trial prior to the session provided higher ratings in response to the post-session question: “How much do you feel that your concentration influenced what colours came up?”

A difficulty with investigating the relationship between practice quality and the illusion of control is that instructing participants to practice or to practice more (e.g., for 10 trials as opposed to one trial) could have demand effects. Specifically, it could cause participants to believe that the experimenter considers the task a controllable one in which practice is effective. In recognisable chance tasks like psychokinesis, this could result in participants answering post-experimental questions about controllability more affirmatively than they otherwise would have, so as not to offend the experimenter. In less recognisable tasks (e.g., a slot machine with a never-before-seen reel-stopping lever), the experimenter could, in issuing the instruction to practice, come to be viewed as having inside knowledge that the task is, in fact, controllable (e.g., via the lever).

1.5. Opportunity for competition

Langer’s final investigation concerned the influence of competition. Participants played a card-drawing game (who draws a higher card?). One group played against a competent ‘dapper’, while another faced a dishevelled ‘schnook’. Across four trials participants facing the weaker opponent bet more. Langer took this finding as evidence in support of her postulation that illusory perceptions of control emerge due to the presence of skilled-task features. Competition, she argued, is a typical feature of skilled tasks. A problem with this interpretation is that the manipulated variable was not opportunity for competition, but competition quality, levels of which vary independently of whether a task is skilled or not. Subsequent studies genuinely concerned with opportunity for competition (i.e., its mere presence) failed to show significant effects (Budescu & Bruderman, 1995; Rudski, 2001).

1.6. Success-frequency

Since Langer's original study series, researchers have sought to not only replicate identified influences, but suggest additional ones. Among these additional suggested influences is success-frequency – the number of successes experienced during multiple trials of a task. The illusion of control has consistently been found to increase with increasing success-frequency.

Almost all studies of this effect have used an experimental task and procedure developed by Alloy and Abramson (1979) (see Table 1.1 – the exceptions are Rudski et al., 1999, and Letarte et al., 1986). The task was a novel, custom-built one, involving a single switch and a light. The accompanying instructions explained that the aim of the task is to discover whether light onset was controllable through pressing:

> [T]here are four possibilities as to what may happen on any given trial: 1) you press [the single available button] and the green light does come on; 2) you press and the green light does not come on; 3) you don't press and the green light does come on; 4) you don't press and the green light does not come on. Since it is your job to learn how much control *you* have over whether the green light comes on, as well as whether the green light does not come on, it is to your advantage to press on some trials and not on others, so you know what happens when you *don't* press as well as when you *do* press. (Alloy & Abramson, 1979, p. 451).

Participants then experienced a series of trials (e.g., 40), in which the frequency of light onset was varied between groups (e.g., 25% vs. 75%). The dependent measure was a post-session analogue scale rating of the "degree of control your responses exerted over the light".

Due to the type of dependent measure used in these studies, research on success-frequency effects is potentially affected by the confounding of perceived control with remembered success-frequency. As demonstrated by Jenkins and Ward (1965), the problem stems from the use of the word ‘control’ in the dependent measure. Jenkins and Ward found that ratings of ‘control’ on an analogue scale correlated highly with experienced success-frequency[1] but failed to correlate with answers to less transparent questions about action-outcome contingency – questions not explicitly referring to ‘control’. This finding suggests that people at least sometimes interpret ‘control’ to mean ‘frequency of attainment of the target outcome’. Furthermore, most of the control scales in success-frequency research have been 100-point scales. The scale potentially prompts participants to indicate the percentage of times they obtained the desired outcome. Thus, studies purporting to demonstrate that beliefs about action-outcome contingency are strengthened with increasing success-frequency might, in fact, only show that experiencing a higher success-frequency leads people to recall more successful outcomes.

1.7. Success-slope

In a study that attracted three direct replication attempts, Langer and Roth (1975) examined the illusion of control as a function of the slope of successes in the experimental session. Participants had the task of predicting the outcomes of a coin toss over 30 trials. Unbeknownst to them, the correctness feedback provided after every trial followed a predetermined order, with successes concentrated at the beginning (descending success-slope), evenly dispersed (flat success-slope), or concentrated at the end (ascending success-slope). When compared to participants in the two other groups, those who experienced a descending slope remembered being successful on a larger number of trials, judged themselves to be better at the task, and expected to be more successful on future trials.

This finding was replicated almost exactly in three further studies (Burger, 1986; Coventry & Norman, 1998; Ladouceur & Mayrand, 1984). One of these studies (Burger, 1986), in addition, found the ‘descending’ slope to result in higher ratings on a more direct measure of perceived control – a scale enquiring about the extent to

[1] Jenkins and Ward found this to be the case regardless of whether there was an actual action-outcome contingency, but Alloy and Abramson (1979) did not observe the correlation in a task with actual contingency.

which participants believed their correct predictions to be the result of their ability to anticipate events (Burger, 1986).

The effects of success-slope remain contested, however. In part, this is due to the fact that an investigation by Matute (1995) produced the opposite pattern: greater certainty in an illusory playing strategy following exposure to an ascending success-slope. Another reason is that, in all but Matute's study and the study by Burger (1986), perceived control was expressed in terms of remembered success-frequency even though success-slope is a factor that potentially affects perceived control and remembered success-frequency differently. Perceived control might be higher in the late-successes (ascending slope) condition because that condition produces an impression of learning (Matute, 1995). Meanwhile, for remembered success-frequency, the early-successes (descending slope) condition could give rise to the highest estimates as part of what research on memory terms the 'primacy effect' . The effect refers to the consistent finding that items presented early in a list are remembered better (see Davelaar et al., 2005, for a debate on why the effect occurs). Among the studies that observed greater perceived control amidst early successes, only one (Burger, 1986) included a dependent measure not related to remembered success-frequency. The dominant finding in the set of studies on success-slope could, therefore, be a replication of the primacy effect, rather than a finding relating to perceived control.

The primacy effect has often been observed in conjunction with a 'recency effect' involving better memory for last items (again, see Davelaar et al., 2005, for an explanation). It is then puzzling that better memory and the associated higher success-frequency estimates were not also observed in the ascending success-slope condition. One explanation for this is that the recency effect is easily disrupted by interference tasks (e.g., thinking about something else; e.g., Glanzer & Cunitz, 1966). In this case, interference might have occurred between the end of the experimental session and the time when the success-frequency questions were answered.

1.8. Need for the outcome

The effects of need for the outcome were established in a series of lottery-based experiments by Biner and colleagues (see Table 1.1). In one of these (Biner, Huffman, Curran & Long, 1998), the high-need group were instructed to fast (skip breakfast and lunch), thus arriving hungry to a lottery game in which the prize was a hamburger. Analogue scales administered prior to the lottery drawing showed that hungry participants were more confident of winning and thought that a greater degree of skill was involved in the lottery. Other studies have shown that greater degrees of controllability on an analogue scale are reported when target outcomes are linked to monetary rewards as opposed to intangible 'points' (Gino, Sharek & Moore, 2011; Thompson et al., 2004), and when target outcomes are linked to no consequences as opposed to electric shocks (Friedland, Kienan & Regev, 1992).

1.9. Strength of belief in luck

In a number of experiments Wohl and Enzle (2002, 2009) showed that confidence of winning in gambling tasks was influenced by degree of belief in the power of luck, in interaction with certain situational factors. One experiment (Wohl & Enzle, 2002), for example, showed that scores on the Belief in Good Luck scale (Darke & Freedman, 1997) interacted with opportunity for choice in influencing confidence of winning in a lottery. That is, greater confidence was reported when the opportunity for choice combined with strong beliefs in luck.

Another experiment – one in a series of similar experiments (Wohl & Enzle, 2009) – began with a confederate describing herself as extremely lucky or, in the control group, not commenting on her luckiness. The experimental task involved choosing a scratch-and-win lottery ticket from a set displayed on the shelf, and participants had the option of letting their partner, the confederate, choose it for them. In the 'lucky partner' group, 10 of 15 participants selected this option, compared to only four in control group. Ratings of confidence in winning were obtained, as were ratings of how strongly one believed their partner to be a lucky person. Stronger beliefs in the partner's luckiness led to the greatest confidence in choosing a winning ticket when the partner described herself as lucky. Thus, an interaction was observed between the availability of a task partner who claimed to be lucky and strength of belief that this claim means something.

1.10. Foreknowledge

Foreknowledge refers to whether bets are placed prior to the outcome's determination, as opposed to afterwards. In one of the three studies observing this factor's influencing effects, Strickland, Lewicki and Katz (1966) found that participants were more risk-seeking and bet more in a dice-throwing task when betting before rather than after throws. In explaining the finding, the authors argued that, compared to postdiction, foreknowledge allows for more magical thinking and talking to the dice, thus enhancing perceived control. An alternative explanation is that foreknowledge is a typical feature of gambling tasks, so its absence caused participants to become suspicious that the game was rigged in some way. Suspicion would have, in turn, resulted in less risk-seeking.

1.11. Personality factors

Another extension of Langer's original work has involved investigating whether certain personality factors or individual differences make some people more prone to the illusion of control. One proposal has been that individuals differ in their susceptibility to the illusion because of differences in locus of control, the extent to which people believe to have personal control across a variety of situations (Rotter, 1966). In defining the locus of control, it was proposed that people with a more 'internal', as opposed to 'external', locus of control believe desired outcomes to be more controllable. A number of instruments have been designed for locating people on the internal-external continuum and there has been some debate about their validity (Lefcourt, 1966). These debates aside, hypotheses and findings regarding the effects of the locus of control on the illusion of control have been mixed. The dominant hypothesis has been that internal individuals are more susceptible to the illusion of control, but only two of the four associated studies produced supporting evidence (see Table 1.1). Hong and Chiu (1988), in fact, hypothesised and observed the opposite effect.

Another trait variable investigated in relation to the illusion of control is desirability of control, the degree to which control is generally attractive. After developing a measure of the trait (Burger & Cooper, 1979), Burger and colleagues (see Table 1.1) found that only people in whom this trait is more pronounced were susceptible to the standard effects of foreknowledge and stimulus familiarity. However, with respect to foreknowledge, Wolfgang, Zenker and Viscusi (1984) did not replicate this finding. Given the inconsistency and paucity of this research, the extent to which the desirability of control is an enabling factor for the illusion of control remains highly questionable.

1.12. Depression

It has been suggested that depression inhibits the illusion of control (e.g., Alloy & Abramson, 1979), but the disorder has so far only been established as an inhibitor of the effect of higher success-frequency on the illusion. The evidence comes from the same set of studies that identified high success-frequency as a cause of the illusion (among non-depressed individuals), so the body of work on the inhibitory effects of depression is substantial. However, if depression is an inhibitor of the illusion of control, people with depression should be found not to experience higher levels of the illusion of control in response to increases in other known influencing factors – factors such as choice and physical involvement.

1.13. Anxiety

Finally, just as depression has been suggested to be an inhibitory factor for the illusion of control, anxiety has been suggested to have an enhancing effect. The associated experiment was concerned the effects of temporary anxiety. Friedland, Kienan and Regev (1992) administered a survey about hypothetical lottery situations to a group of airforce cadets at a relatively relaxed stage of a flying course (low anxiety) and to a group about to undertake a decisive practical exam (high anxiety). All survey items related to whether the respondent preferred to choose a lottery ticket himself or have the ticket chosen through another mechanism (e.g., random-number generator, friend's selection). The high-anxiety group showed a stronger preference for personally choosing the ticket, which implied that they considered their actions more effective. Further replications of this effect are required.

1.14. Summary

Over a dozen influences on control perceptions in tasks with random outcomes have been identified based on empirical results. Findings concerning the effects of choice and physical involvement appear particularly robust, as is also the case with need for the outcome and depression in interaction with success-frequency. The effects of personality factors and anxiety, on the other hand, have received considerably little attention, partly because, within Langer's overarching paradigm, the illusion of control is considered a general effect. The extent to which the other identified influences are real also requires further investigation, since all have been investigated in only a handful of studies.

Success-frequency and success-slope stand out as factors whose effects remain ambiguous. The ambiguity is due to the potential confounding of perceived control with remembered success-frequency, and, in the case of success-slope, there is also the issue of conflicting findings. For stimulus familiarity and foreknowledge, there is the question of whether their presence increases the illusion of control, or whether their absence gives rise to suspicion, which, in turn, lowers perceived control levels. The effects of opportunity for practice are also ambiguous because, in being instructed to practice, participants could come to think that the experimenter believes or knows the task to be controllable.

2. Psychological processes: attempted explanations

As noted earlier, Langer (1975) proposed that the illusion of control increases with the amount of choice, physical involvement, stimulus familiarity, thinking time, practice and competition because these are features of skilled tasks that encourage strategic thinking and behaviour when present in games of chance. A limitation of this explanation is that it is unclear why participants in Langer's lottery-style experimental tasks did not conclude that no effective strategies exist, regardless of their experimental condition. After all, in lotteries, the number of possible actions is highly limited. Research on factors influencing the illusion of control has formed the basis for other explanations of the psychological processes underlying the illusion. This section summarises the rationales and limitations of these explanations.

Langer provided a supplementary 'motivational' explanation of her findings, arguing that people ignore the chance elements of all tasks (not just games of chance) because broader ego-protective mechanisms motivate people to generally perceive actions as being effective in obtaining a desired outcome. Langer did not make clear why the motivation for control should result in greater neglect of chance features in the presence of particular task features (choice, physical involvement, etc.), but subsequent theorists made a suggestion in this respect (Cummins & Nistico, 2002; Friedland, Kienan & Regev, 1992; Leotti, Iyengar & Ochsner, 2010). These theorists point out that lotteries of the kind investigated by Langer offered no opportunities for action, except through ticket choice. Thus, the ego-protective mechanisms operated only in the choice group, giving rise to an illusion of control in that group. The theorists have gone further in pointing out that, although Langer distinguished between opportunity for choice and other factors, many of the factors she investigated were, in fact, vehicles for action in the same way that choice is. Extra physical involvement, stimulus familiarity, thinking time, practice, competition and foreknowledge all provide opportunities for action where none exists. Unfortunately, a key limitation of this explanation is that some of Langer's lotteries and many other experimental tasks permitted some action before the introduction of choice and related factors. For example, physical involvement had an effect in a roulette task where participants could already choose numbers to bet on (Ladouceur & Mayrand, 1987). In other words, giving people an opportunity to take actions might increase the likelihood of control being inferred via motivational mechanisms, but motivational mechanisms cannot account for why the *number* of action alternatives also influences perceived control.

Another explanation of influencing factors that focuses on Langer's original lottery studies attributes participants' reluctance to exchange tickets for ones with better odds to anticipated regret if an exchanged ticket were to win (Bar-Hillel & Neter, 1996; van de Ven & Zeelenberg, 2011). Being allowed to choose the lottery ticket, in turn, makes the anticipated regret and subsequent degree of reluctance to trade even stronger (Risen & Gilovich, 2007). Problematically, this explanation applies only to the limited range of Langer's original experiments that used preparedness to exchange tickets as the dependent variable.

An alternative explanatory approach has focused on the success-frequency effect and its disappearance among depressed individuals. According to this approach, the success-frequency effect is an instance of causal learning (Crocker, 1981; Jenkins & Ward, 1965). Causal learning involves forming a conclusion about whether a candidate cause and an outcome are causally related. The conclusion is made following some experience with a sequence of the events occurring together and separately. In laboratory experiments, the conclusion is made based on presented information (e.g., in a table) about the number of times the candidate cause and effect co-occur, the number of times they are mutually absent, and the number of times they occur separately. When, objectively, there is no causal relationship between the candidate cause and effect (i.e., when their co-occurrence rate is equal to the rate at which the effect occurs on its own), people have still been found to infer a causal relationship, with stronger inferences accompanying increasing co-occurrence frequency.

Several explanations of this judgement pattern have been developed – and all suggest that it is a by-product of broader adaptive ways in which people reason about causal relationships (Griffiths & Tenenbaum, 2005; Oaksford & Chater, 1994, 2001). In a similar vein, the effect of success-frequency has also been described as a conditioning effect (e.g., Matute, Vadillo, Vegas & Blanco, 2007; Rudski, Lischner & Albert, 1999). Whatever the exact etiology of the success-frequency effect, its non-occurrence in depressed individuals may be influenced by the depressed participants' disinterest in responding in the button-and-light task. Depressed participants press the button fewer times, and therefore experience fewer instances of press-light co-occurrence, which drives both causal learning and conditioning (Blanco, Matute & Vadillo, 2009; Matute, 1996).

Finally, a recent 'control heuristic' explanation of the illusion of control proceeds from the assumption that the illusion is a bias resulting from the use of a specialised heuristic for judging the degree of personal control over an outcome (Thompson, Armstrong & Thomas, 1998). The explanation posits that, whenever a judgement of control is required, contingency judgement patterns combine with ego-protective considerations in driving the judge to look for confirming evidence of his effectiveness as an agent. The chief problem with this explanation is that it does not specify when judging the degree of personal control is an adaptive task for the cognitive system to perform (Chase, Hertwig & Gigerenzer, 1998). As a result, the explanation is silent on why participants in chance tasks make control judgements unless they are in an experiment and are asked to do so in a post-experimental questionnaire. Indeed, in most of Langer's studies and many other studies, explicit judgements of control were not required. The degree of illusion of control in these studies was extrapolated based on behavioural indices, such as bet amounts and preparedness to swap a lottery ticket for one with better winning odds. The control heuristic explanation does not account for why participants in these tasks were necessarily assessing their degree of control, with the degree of perceived control then being reflected in their behaviour.

At any particular moment in time, behaviours and questionnaire-based control judgements in games of chance could reflect motivational processes, anticipated regret, causal learning, and certain heuristics. However, alone, each of these constructs is relevant to explaining only one or two of the factors found to influence the illusion of control. Moreover, the explanations often do not extend to particular experimental tasks. In the next section, we propose that a large proportion of the experimental findings relating to influences on the illusion of control can be accounted for if it is recognised that people engage in *problem-solving* as they try to obtain a gambling win.

3. Psychological processes: a proposed explanation

The explanation of the illusion of control advanced in this thesis expands on Langer's (1975) original explanation, and, in particular, Langer's proposal that people in gambling tasks engage in strategic thinking and behaviour. Langer suggested that the presence of certain task features (choice, physical involvement, etc.) results in an increased likelihood of strategic behaviour in gambling tasks. According to Langer, this is because choice, physical involvement and the other factors she investigated are features of skilled tasks and cause confusion as to whether the gambling task at hand might involve some skill. The explanation provided here draws on cognitive-science-based research on problem-solving in making an alternative suggestion. According to the present explanation, in all tasks, including gambling, additional opportunities for choice, physical involvement, stimulus familiarity, thinking time, practice, competition, and foreknowledge imply an increase in the range of actions available for trial during strategising. This leads to more protracted strategic behaviour (Section 3.1). The argument is then made that, to account for why increases in choice, physical involvement and so on, lead to substantial strategising even in lotteries, the influence of 'background beliefs' on problem-solving needs to be recognised (Section 3.2). It is further argued that background beliefs of particular relevance in gambling settings are beliefs about supernatural agents such as God and luck (Section 3.3) and the gambler's fallacy, the widespread expectation that random outcomes self-correct even in the short term (Section 3.4). Thus, the proposed explanation accounts for findings relating to a wide range of influencing factors across a variety of experimental tasks. The explained findings include those relating to strength of belief in luck.

3.1. The illusion of control as problem-solving

It is possible that findings on some of the factors that influence the illusion of control reflect problem-solving in games of chance. Problem-solving is a search for an action that satisfies a goal or brings the goal state closer, and where action alternatives are evaluated through direct trial or mental simulation (e.g., Anderson, 1993). In a game of chance, the goal state is a sizeable win (Walker, 1992b). There are no effective action alternatives in games of chance, but increases in the number of different response alternatives can lead to increases in the number of actions that need to be evaluated before concluding that this is the case. Thus, amidst greater choice, all other things being equal, there is a longer period during which players continue to search. If measures of perceived action effectiveness (e.g., bet amounts, post-experimental judgements) are obtained at a point when participants with fewer action alternatives have exhausted their search, there is some likelihood that participants with more action alternatives are still in the process of searching. Participants still in the process of searching may then display greater relative perceived control because they are unsure about the effectiveness of a number of possible actions instead of being sure that no action is effective. Physical involvement, stimulus familiarity, thinking time, practice, competition and foreknowledge might also broaden the number of apparent action alternatives. Presumably, also, the length and thoroughness of the search for effective actions increases with increasing need for the outcome.

A real-world illustration of the effect of adding action alternatives is provided by the scenario of two slot machine players. The players use slot machines that are identical in every respect, except in that one has a 'progressive jackpot' feature (Delfabbro & LeCouteur, 2003). This feature is a stand-alone screen that displays a monetary figure that gradually increases over the course of play. Specifically, a small percentage of the player's bet amount in each round is added to the total. Winning the jackpot requires reaching a randomly-determined trigger point – that is, a particular monetary figure. After 100 rounds, the jackpot has not been won, neither player has won substantial money, and both players have exhausted the search for effective slot-machine playing actions. The players are asked about the degree of control they perceive over the game. The player with the jackpot feature is likely to provide higher control estimates, as he is more likely to still be in the process of trialling the action of persevering so as to reach the jackpot trigger point.

The problem-solving approach can also account for the effects of success-frequency and Matute's (1995) isolated finding of greater perceived control following an ascending success-slope (i.e., late successes). As features of the experienced sequence of outcomes, success-frequency and success-slope serve as feedback on the effectiveness of chosen actions. Actions contiguous with high success-frequency could, thus, come to be considered problem solutions. A concentration of successes late in the session could come to be judged a result of successful action search in which ineffective alternatives were discarded over time.

3.2. The role of background beliefs

Although accounting for the majority of identified influences on the illusion of control, the problem-solving explanation is, in its present form, unable to account for why the illusion occurs in tasks where players have to evaluate few action alternatives. Langer's lotteries are a case in point. The only possible action in one of these lotteries was choosing a ticket with a particular symbol. After mentally simulating the effects of this action on the lottery result, why did participants not discard it as being ineffective?

The answer may have something to do with the beliefs people hold about lotteries. In the problem-solving literature, background beliefs are defined as theories of the world that generate action alternatives for evaluation (Chi, Feltovich & Glaser, 1981; Murphy & Medin, 1985; Tenenbaum, Griffiths & Niyogi, 2007; Thagard, 1992). Due to the influence of beliefs, generated alternatives can vary in type, number, or both simultaneously. Chi et al. (1981) demonstrated this in an experiment in which they varied background beliefs. Trained physicists were compared to novices in how they categorised a set of physics problems. Physicists created a small number of categories based on the Newtonian Laws required for solving the problems, whereas novices created a large number of categories on the basis of the problems' surface features, such as whether they referred to inclined planes. Thus, background beliefs influenced both the type and number of generated alternatives. In a lottery setting, background beliefs could cause the one available action alternative (e.g., choosing a ticket) to be considered effective. Alternatively, the beliefs could cause the action to be seen as more than one action, with the search between action alternatives therefore being more extensive. The beliefs could be common to all participants or differ across individuals, as in the physics example.

Thus, to provide a more complete account of the illusion-of-control findings, the problem-solving explanation needs to incorporate a notion of generative background beliefs. To then make claims about the number and type of action alternatives generated by the beliefs, the explanation also needs to incorporate a notion of what the relevant beliefs might be and whether they differ across individuals. Potentially relevant beliefs are considered in the next two sub-sections.

3.3. Beliefs about luck and the illusion of 'secondary' control

Up to this point, the illusion of control has been defined as the perception of action-outcome contingency following problem-solving in games of pure chance. As problem-solvers, gambling participants search among action alternatives for one that increases the probability of a profitable outcome. It is puzzling that the search persists even in lotteries, where there seem to be very few action alternatives. However, in problem-solving, the set of action alternatives is generated in line with background beliefs. Thus, to explain the illusion of control in a lottery environment, it might be necessary to explore the beliefs people bring to lottery settings.

Empirical evidence that beliefs about luck are one type of belief people bring to lotteries is among the body of findings relating to the illusion of control. Wohl and Enzle (2002) noticed that lotteries are peculiar not only in that participation in them involves few actions, but also in that there is no physical mechanism connecting the actions to game outcomes. The researchers concluded that participants must believe in a non-physical connecting mechanism – 'luck'. Wohl and Enzle (2002, 2009) speculated that luck is non-physical in that it is believed to be a personal quality.

One of Wohl and Enzle's experimental findings was consistent with this proposal. The presence of a gaming partner who described herself as lucky caused participants to ask her to choose a lottery ticket on their behalf and, subsequently, to have greater confidence in winning (Wohl & Enzle, 2009). Another of Wohl and Enzle's findings, however, did not rule out the possibility that luck is also believed to be a force *external* to the individual. In the relevant study (Wohl & Enzle, 2002; Study 1), manipulating the degree for choice in a lottery task had more effect on people with higher scores on the Belief in Good Luck scale, a measure of degree of belief in the power of luck as an external force (Darke & Freedman, 1997). It is also possible that participants appreciated ticket choice because they saw the choice as an opportunity to make use of personal luckiness.

In a sense, Wohl and Enzle's findings are consistent with literature review work by Rothbaum, Weisz and Snyder (1982), who argued that that there are two types of illusion of control. The first, an illusion of 'primary' control, is any attempt to bring about gambling wins through actions physically connected to them, whereas the illusion of 'secondary control is the attempt to bring about gambling wins with the aid of non-physical "larger" forces, such as luck (p. 11). According to this view, people believe luck to be but one non-physical mechanism that could connect actions and outcomes. Other non-physical forces people might believe in are divine intervention and astrology. In effect, people attempt to influence outcomes by "aligning" themselves with these forces (p. 17). Alignment often involves some form of ritual (Wohl & Enzle, 2002). It follows, therefore, that providing people with greater opportunities for action in a task may allow for a greater range of magical beliefs to be applied and for a greater range of ritual actions to be performed. Rothbaum and colleagues argued that, in lotteries, stimulus familiarity and greater thinking time have exactly this effect.

Rothbaum and colleagues acknowledged that stimulus familiarity and thinking time broaden opportunities for action in lottery tasks, facilitating magical actions aimed at alignment with larger non-physical forces. Meanwhile, Wohl and Enzle (2002; Studies 2 and 3) demonstrated this to be the case for physical involvement. For example, in one experiment, the numbers of a wheel-of-fortune were displayed on halves of ping-pong balls, and the game involved betting on one of the numbers by drawing a numbered ball from a bowl. The ball could then be brought back to the table, on which three other objects – a clipboard, a pencil, and an elastic band – were already positioned, as if by accident. Manipulated within subjects, across ten spins, was the outcome at stake. On half the spins it was one's own; on the other half it was one's opponent's. Video tapes of the participants' hands revealed that the ping-pong ball was handled significantly longer during the player's own turns and that this behaviour was not displayed towards the other objects. Thus, the opportunity for physical involvement – the opportunity to be in physical contact with the ping-pong ball while sitting at the table – facilitated magical actions that would not have been possible otherwise.

In summary, a theoretical proposal by Rothbaum et al. (1982) and the recent work of Wohl and Enzle (2002, 2009) suggest that people have background beliefs concerning the influence of larger non-physical forces. These beliefs generate a number of action alternatives in lottery tasks, which, otherwise, appear to involve no action alternatives apart from ticket choice. Due to background beliefs in luck and God, praying for a win and performing devotional rituals are believed by some to be possible action alternatives in a lottery without ticket choice. The ability to make one's own ticket choices affords additional opportunities, including the exercise of personal luck and the ability to select from a range of lucky numbers or symbols. Beliefs could, further, dictate that alignment with these putative forces requires praying or performing rituals before choosing the ticket. Alignment could also involve using lucky signs to guide choice. With these additional action alternatives to consider, participants with ticket choices engage in more extensive problem-solving than those without. The same has been shown to be the case for participants with extra physical involvement.

One might question whether such clearly erroneous beliefs are widespread enough to cause an effect as general as the illusion of control. But there is strong anthropological and archaeological evidence to suggest that such beliefs are a common feature of human societies (e.g., Felson & Gmelch, 1979; Risen & Gilovich, 2007). Indeed, it is likely that such beliefs have evolutionary or functional explanations. Although many beliefs are culture-specific or even specific to individuals, the wider literature on the nature of background beliefs suggests that beliefs varying across situations and individuals can still have communalities that derive from more abstract belief *structures*. These structures evolve directly or as side-effects of evolved cognitive capacities (Atran, Estin, Coley & Medin, 1997; Dennett, 1987; Wellman & Gelman, 1992). In fact, the literature defines a hierarchy of beliefs, with abstract belief structures common to all humans at the top, and highly situation-specific beliefs at the bottom. The abstract belief structures generate and constrain more situation-specific ones. For example, an abstract theory of mind is generally necessary before one is likely to start making inferences about the possibility of an opponent's bluffing in poker. Atran and Norenzayan (2004) identified an abstract belief structure that may generate beliefs about non-physical, or 'supernatural'[2], phenomenon. Moreover, these authors explained how such a structure might emerge as a side-effect of evolved emotional and cognitive capacities. The structure itself has three interacting components: (a) beliefs in omniscient supernatural agents (gods, ghosts, angels, luck etc.); (b) beliefs that these agents can avert death and other cataclysms; and (c) beliefs about rituals that can be used to appeal to the agents. Religious beliefs, superstitions, beliefs in lucky numbers, and beliefs in good luck being a personal quality of good people are all examples of less abstract beliefs constrained by this belief structure.

A problem with this line of explanation is that it hinges on a theoretical rather than empirically supported proposal by Rothbaum and colleagues. Qualitative evidence of gamblers' appeals to luck and rituals is abundant (e.g., Henslin, 1967; King, 1990), but formal evidence for the existence of two illusory control variants is limited. The available evidence comes from factor analyses of two surveys in which respondents indicated their degree of agreement with statements expressing erroneous beliefs about gambling (Steenbergh, Meyers, May & Whelan, 2002; Wood & Clapham, 2005). The statements corresponded to expressions of the illusion of control, since they were sourced from interviews in which people who gamble regularly described the actions they considered effective when gambling. In both studies, two factors were uncovered, with one containing statements about non-physical phenomena – statements such as "I believe that fate is against me when I lose" and "I can improve my chances of winning by performing special rituals". However, analyses of other surveys of this type did not uncover the same two-factor structure (Jefferson & Nicki, 2003; Raylu & Oei, 2004). To compare and evaluate the obtained factor

[2] Atran and Norenzayan's (2004) formal definition of a supernatural entity is as an entity not directly classifiable as a 'person', 'plant', 'animal', or 'substance'. That is, under this definition, supernatural entities are 'counterintuitive' with respect to categories of ordinary ontology. The notion of an entity that can part seas without being physically solid is counterintuitive in this sense.

structures, further insight into the nature of the illusion of primary control might be needed. Rothbaum and colleagues' proposal, as discussed so far, amounts to the proposal that the illusion of secondary control is a conclusion about action effectiveness in games of chance, driven by an abstract set of beliefs about supernatural phenomena. By implication, the illusion of primary control must be driven by belief structures about non-supernatural phenomena. It might be useful to consider whether the illusion is better defined simply as being driven by all belief structures about non-supernatural phenomena, or whether some belief structures are particularly relevant. This topic is discussed in the next sub-section.

3.4. The gambler's fallacy and the illusion of 'primary' control

In a bid to explain the illusion of control in lotteries specifically, the preceding sub-section concerned itself with beliefs about luck. It was concluded that that both theory and evidence point to these beliefs being very likely influenced by more abstract belief structures relating to supernatural agents such as God and fate. Attempts to work out how to succeed in the task (problem-solving) could, therefore, be informed by any of these beliefs and lead to the development of a particular kind of illusory of control – the illusion of secondary control. Can the same logic be applied to the illusion of primary control? That is, can abstract belief structures influencing it be identified? This thesis argues that one strong candidate belief structure is the well-known gambler's fallacy. The fallacy is the expectation that random sequences tend to self-correct even in the short-term, producing a 'head' after a series of 'tails' in a coin toss game, a 'red' after a series of 'blacks' in roulette, and a win after a series of losses on slot machines. The gambler's fallacy is likely to be a defining feature of the illusion of primary control because, as argued below, it is an abstract belief about gambling and random sequences that is not directly concerned with supernatural agents.

One reason that the fallacy can be considered an *abstract* belief about gambling is that a large number of studies point to it being unavoidable in tasks where outcomes are described to participants as random. Specifically, over 40 laboratory studies on the identification and production of random binary sequences (e.g., sequences of Heads and Tails) have shown that people associate randomness with a long-run outcome alternation probability of .6, even though, objectively, random binary sequences have an alternation probability of .5. For example, in randomness-identification tasks, people label less-alternating strings such as HTHHHHHH non-random. The association between randomness and alternation is not so strong that perfectly alternating strings such as HTHTHTHT are judged to be random. Rather, people display an expectation of negative recency – that is, an expectation that the probability of alternation increases with each repetition (for reviews, see Nickerson, 2002, and Oskarsson, Van Boven, Hastie, & McClelland, 2009). The universality of a negative recency expectation for random sequences is further corroborated by studies of gambling activity. In lotteries, drawn-out numbers have been found to drop in popularity (Clotfelter & Cook, 1991, 1993; Terrell, 1994). Blackjack players have reported that they prefer playing on two ‘boxes’, as they expect poor outcomes on one to be balanced out by favourable outcomes on the other (Keren & Wagenaar, 1985). When participants were asked to speak aloud their thoughts during laboratory gambling sessions on slot-machines, roulette and blackjack, approximately 60 percent reported expecting a certain outcome because ‘it hadn’t come up lately’ (Baboushkin, Hardoon, Derevenky & Gupta, 2001).

The gambler’s fallacy is also implied to be unavoidable, and, therefore, abstract, by theories of why it arises. Estes (1964) proposed the fallacy to be a product of a more abstract rational belief that many real-world outcomes follow a law of sampling without replacement. A harvested crop, for example, contains only a finite number of defective specimens. Tversky and Kahneman (1974) suggested that the gambler’s fallacy is a product of a belief in the fairness of long-run random sequences. This belief is not fallacious, but a fallacy arises through the largely inevitable (heuristic) reasoning that smaller samples (in this case, shorter random sequences) possess the essential properties of the parent population (in this case, longer random sequences). According to a still different proposal by Hahn and Warren (2009), the gambler’s fallacy is an inevitable result of having a limited working memory and only ever experiencing finite sequences of random events (e.g., 20 rolls of a die in a board game). Notably, the last two explanations pre-suppose that random sequences are identified to people through formal instruction, which is likely to occur only in developed societies (Aubert, 1959; Bork, 1967). Nevertheless, all explanations attest to the gambler’s fallacy being unavoidable amongst participants in Western games of chance.

As an abstract (i.e., unavoidable) belief in gambling settings, the gambler's fallacy could engender the illusion of control in a similar manner to how abstract beliefs about supernatural forces make people prone to the illusion of secondary control. That is, it could generate beliefs about what lottery numbers to choose (ones that have not been drawn out for some time), what slot machines to choose (ones that have not produced a win for some time), how long to play for, and so on. These beliefs could, in turn, generate specific action plans to be evaluated during problem-solving.

As a belief about chance, a *non-supernatural* phenomenon, the gambler's fallacy is an obvious candidate for being one of the belief structures underlying the illusion of primary control. Up to this point, the illusion of primary control has been defined as an action-outcome contingency perception informed by all beliefs except beliefs about supernatural agents and forces. With the gambler's fallacy added as an explanatory construct, the illusion of primary control can now be defined as a perception of action-outcome contingency arising from the gambler's fallacy or other non-supernatural beliefs in a game of chance. Examples of control perceptions informed by the gambler's fallacy have been discussed throughout this section, and include beliefs in the effectiveness of selecting lottery and roulette numbers that have not been drawn out recently, and playing on two boxes in blackjack in expectation that they will 'balance' each other out. An example of control perceptions informed by other beliefs about physical phenomena is the belief that slot machines should not be played during 'peak' gambling times such as public holidays because the machines are programmed to pay out less on such days (Livingstone, Wooley & Borrell, 2006).

The previous sub-section concluded with the suggestion that insight into the nature of the illusion of primary control could represent a step forward in formally testing Rothbaum and colleagues' proposal that the illusion of control has two variants. Some existing factor analyses of surveys where items express the illusion of control have revealed two underlying factors (Steenbergh et al., 2002; Wood & Clapham, 2005), but others have not (Jefferson & Nicki, 2003; Raylu & Oei, 2004). Given the present additional clarification regarding the nature of the illusion of primary control, it might be possible to explain why some surveys did not lend themselves to a two-factor structure. For example, in Jefferson and Nicki's (2003) survey, most items reflected the gambler's fallacy, so it is unsurprising that a factor analysis identified only a single factor.

The present additional clarification regarding the abstract beliefs underlying the illusion of primary control might also make some of the structures produced by factor analyses of erroneous-beliefs surveys more interpretable. For example, Steenbergh and colleagues (2002) uncovered a two-factor structure in which one factor was defined by statements reflective of the illusion of primary control (e.g., "My knowledge and skill in gambling contribute to the likelihood that I will make money") and the other was defined by beliefs about 'luck' and the value of 'perseverance'. On the face of it, luck and perseverance do not seem related. Beliefs in luck reflect the illusion of secondary control, whereas beliefs in the value of perseverance seem to follow from the gambler's fallacy and hence reflect the illusion of primary control. However, under the present explanation of the illusions of primary and secondary control, it is possible that, as an abstract belief, the gambler's fallacy might combine with beliefs about the supernatural in informing some aspects of the illusion of secondary control. Namely, it might combine with abstract supernatural beliefs in shaping the belief that luck, a supernatural force associated with games of chance, acts in accordance with supposed laws of chance, never allowing cycles of bad or good outcomes to continue for long. This belief in the cyclical nature of luck has been widely documented (e.g., Duong & Ohtsuka, 2000; Keren & Wagenaar, 1985). The 'Luck/Perseverance' factor identified by Steenbergh and colleagues might capture this belief in the cyclical properties of luck alongside other beliefs about the supernatural elements of games of chance.

3.5. Summarising the proposed explanation

According to the present explanation for the body of findings on the illusion of control, some of the findings can be explained simply by assuming that judgements and behaviours indicating control perceptions are preceded by a problem-solving process. At the time the judgements and behaviours are assessed, the problem-solving process, a process of searching for an effective action, is not necessarily complete. If at the time of measurement the participant is still in search of an effective action, or believing to have found it, her judgements and behaviours convey a perception of control. Choice, physical involvement, thinking time, practice, need for the outcome, and foreknowledge enhance the degree of perceived control by broadening the range of action alternatives available for the search. Participants experiencing higher levels of these factors are more likely than the comparison group to still be searching for an effective action at the time of control perception measurement. Other factors – namely, success-frequency and success-slope – can enhance the perceived effectiveness of the alternative being trialled at the time of control perception measurement. Participants experiencing high success-frequencies or an ascending success-slope are more likely than the comparison group to believe in having found an effective action at that point.

Additional constructs – namely, belief constructs – are needed to explain the observed effects of choice and other action-broadening factors in lotteries. It is difficult to see how search length could vary substantially across groups in these contexts because they appear to allow for few actions on the participant's part. The present explanation proposes that people have an evolved set of beliefs about supernatural phenomena, which cause them to see numerous action alternatives in lotteries. The beliefs also inform problem-solving in other gambling tasks and outside the gambling context (e.g., common superstitions). In gambling tasks, there is also an unavoidable belief in the negative recency of chance outcomes – the gambler's fallacy – and this can drive people to recognise selecting numbers/options that have not won in some time as a potentially effective action. Beliefs about other non-supernatural phenomena (e.g., computer technology) can also influence the actions considered during gambling problem-solving. The illusion of control is, therefore, in line with a proposal by Rothbaum, Weisz and Snyder (1982), defined as having two variants – primary and secondary. If the actions considered and not discarded during action search are based on non-supernatural beliefs, including the gambler's fallacy, an illusion of primary control is captured by the perceived control measures. If, at the time of control perception measurement, some of the actions being considered are informed by supernatural beliefs, there is an illusion of secondary control. The two illusions can occur simultaneously or in isolation.

4. Research directions

The empirical findings on factors influencing the illusion of control leave open a number of research questions, summarised in Section 1.14. This section outlines these research questions in some detail (Section 4.1) before specifying methodological guidelines for addressing them – guidelines based on the proposed psychological explanation of the illusion of control (Section 4.2). As a final possible research direction, Section 4.3 discusses possible approaches to testing the psychological explanation's hypotheses regarding the problem-solving and abstract beliefs underlying the illusion of control.

4.1. Influences on the illusion of control

As indicated in Section 1.14 above, the main questions raised by the body of research on factors influencing the illusion of control relate to the effects of success-frequency and success-slope. In relation to *success-frequency*, the question is whether the factor is an influence at all. In the studies that have demonstrated increases in perceived control with increasing success-frequency, perceived control has consistently been measured using a direct reference to 'control', a term that has been found to be interpreted to mean 'rate of success' (Jenkins & Ward, 1965). The finding of increasing control estimates with increasing success-frequency, therefore, potentially reflects simply a greater number of remembered successes with increases in the objective success rate. To assess whether inferences of control are affected by success-frequency, it is necessary to compare different success frequencies on a perceived control measure that does not directly refer to 'control'.

In relation to *success-slope*, conflicting findings create uncertainty not only as to whether success-slope is an influence, but also as to which success-slopes result in greater perceived control. Four studies have suggested that it is the 'descending' slope (early successes), whereas a study by Matute (1995) points to the 'ascending' slope (late successes). A problem with the former set of studies is that they used estimates of remembered success-frequency as proxies for perceived control. The studies might have, therefore, found evidence of a memory-based primacy effect, rather than evidence of the 'descending' slope's augmentation of perceived control. To determine whether success-slope is an influence on perceived control and whether perceived control increases following a 'descending' slope, 'ascending' slope, or both, further studies need to be conducted using a dependent measure capturing perceived control.

For most *other identified influences*, the associated evidence of their effects is so scant that there is a need for studies aimed at replicating the effects. Studies concerned with the effects of stimulus familiarity, foreknowledge and practice would have additional issues to consider. For example, investigations of stimulus familiarity and foreknowledge could additionally explore the role of suspicion about the game's fairness, whereas investigations of practice could seek to minimise the potential demand effects associated with issuing instructions to practice or practice more extensively.

Broadly speaking, there is a need for research that uses appropriate dependent measures in replicating existing findings about the factors that influence the illusion of control.

4.2. Underlying psychological processes: methodological implications for research on influencing factors

Most of the research questions discussed above call for further studies into whether certain factors (e.g.., success-frequency and success-slope) indeed influence the illusion of control. The present explanation of the psychological processes underlying the illusion of control (see Section 3) has a number of implications for how any such study should be designed to elicit and measure both variants of the illusion. The explanation's main methodological guideline has to do with the recognisability of the experimental task and the associated instructional set. Experimental studies of factors influencing the illusion have differed in terms of task recognisability, such that, for example, in the set of studies on success-slope effects, four studies featured an experimental task with a recognisable gambling format (coin-tossing), while one featured a novel task in which it was explained to participants that they might be able to terminate an unpleasant noise by pressing the correct combination of keyboard keys (Matute, 1995). Instructions explaining the purpose of the task are an essential feature of novel experimental tasks. Arguably, any such instructions limit the extent to which participants apply beliefs about supernatural forces and the gambler's fallacy – beliefs that are, according to the present psychological explanation, defining features of the illusion's two variants.

To expand on this argument, three kinds of designs have been used in studies of the illusion's influencing factors: (a) designs featuring experimental tasks with a recognisable gambling format (e.g., lotteries, roulette, slot machines), (b) designs featuring novel experimental tasks and 'outcome-seeking' instructions, and (c) designs featuring experimental tasks and 'contingency-detection' instructions. Instructions specify the participant's goal in the experimental task. In a recognisable gambling task, instructions are not necessary because the goal is clearly to obtain the target outcome – a match between one's ticket and the drawn-out ticket, for example. In novel tasks, such as those involving a box with a switch or a never-before-seen computer program, the goal of the task requires specification. 'Outcome-seeking' instructions define the aim of the task as the maximisation of a target outcome. Alternatively, 'contingency-detection' instructions introduce the task as one in which the participant should seek to accurately determine the degree of control he possesses over some aspect of the apparatus[3]. Contingency-detection instructions have been used only in success-frequency studies, and the instructional set quoted in describing those studies is an example (see Section 1.6). The following is an example of outcome-seeking instructions:

> From now on, imagine that numbers 1, 2, and 3 are the only keys in the keyboard. From time to time, a loud tone will come on for a while. Try to find the way to stop it. You may either type a number or do nothing. If your response is a number, it can have 1 or 2 digits, but the same digit cannot appear in it twice (Matute, 1995, p. 146; for other examples, see Blanco, Matute & Vadillo, 2009, 2011, and Rudski, Lischer & Albert, 1999).

The problem with outcome-seeking instructions is that they tend to imply that the experimental task is designed around a definite strategy for obtaining the target outcome. To the extent that participants interpret the instructions this way, they proceed to try to solve the problem without entertaining the possibility that outcomes are chance-based. Thus, outcome-seeking instructions result in participants being less likely to apply gambler's fallacy logic or beliefs about supernatural forces. Since, as was argued in Section 3, the gambler's fallacy and beliefs about supernatural forces are defining components of the illusion of control, participants who receive outcome-seeking instructions might not display the illusion of control in any meaningful sense. Contingency-detection instructions have the same effect as a result of defining the task very explicitly, specifying the method by which control might be achieved (e.g., a

[3] Alternative terms for the outcome-seeking and contingency-detection instructional sets are 'naturalistic' and 'analytic', respectively (Matute, 1996).

single button press; see Section 1.6). Overall, the present explanation suggests that task instructions should be avoided, and this can be achieved through the use of recognisable task formats.

Another methodological issue brought to light by the present explanation of psychological processes underlying the illusion of control is that single-scale measures of perceived control, such as Langer's question about performance relative to a champion chess player (see Section 1.4), might have been conceptually confusing for participants. If people have abstract deep-seated beliefs about possible supernatural actions, this possibility has to be acknowledged by measuring the illusions of primary and secondary control separately. Where measures have not referred to action-outcome contingency, relying instead on self-report-based or behavioural measures of confidence in winning, construct validity would not be such a problem.

The present explanation of the psychological mechanisms underlying the illusion of control also proposes that people adopt a problem-solving orientation in gambling tasks. The methodological implication of this proposal for studies on factors influencing the illusion is that post-experimental questions about the effectiveness of various listed action types (e.g., Hong & Chiu, 1988; Rudski, Lischner & Albert, 1999) are more intuitive to answer than questions requiring single global judgements about the task's controllability (e.g., Burger, 1986). If people evaluate numerous action alternatives throughout the session and are still in the process of searching at the moment the post-experimental questionnaire is presented, the listing format should more closely match the contents of the participants' working memory at that moment.

4.3. Underlying psychological processes: testing the present explanation

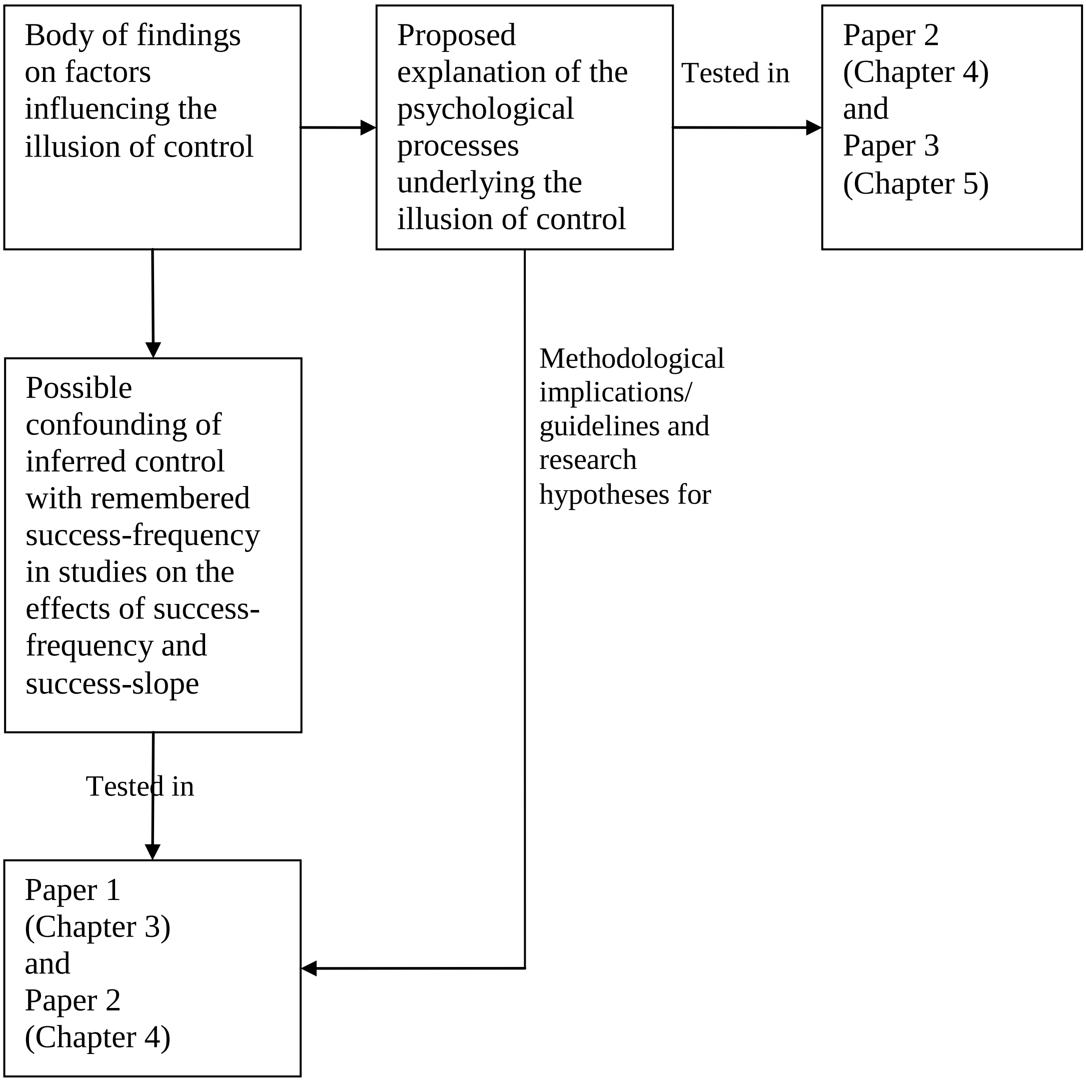
The present explanation of the psychological processes underlying the illusion of control presented in Section 3 is only speculative. To properly justify the methodological guidelines discussed above and provide a genuine test of the advanced explanation, more research consistent with a number of the arguments developed in Section 3 is needed. Firstly, there is a need for evidence which shows that gambling involves *problem-solving*. Secondly, it remains to be shown that the illusion of control has *two variants, reflecting abstract beliefs about supernatural agents and the gambler's fallacy, respectively*.

A piece of supporting evidence for the first proposal would be a finding of greater perceived control in the ascending success-slope condition relative to one or more other conditions. Such a finding would suggest that games of chance are believed to be problem-solving environments in which it is possible to learn the correct response through trial-and-error.

For the explanation's second proposal, a proposal about the two variants of the illusion of control, a testing procedure was discussed in Sections 3.3 and 3.4. The procedure involves factor-analysing a survey about erroneous gambling-related beliefs – that is, a survey in which items reflect (illusory) problem-solving solutions arrived at by people who gamble regularly. If the proposal is correct, it should be possible to classify each survey item with regard to whether it reflects (1) the gambler's fallacy, (2) other non-supernatural beliefs (e.g., about venue operators intervening with slot machines), (3) beliefs about luck and other supernatural agents, or (4) a meaningful combination of these (e.g., the belief that luck is cyclical; see Section 3.4). Various factor-analytic techniques can be used to determine the category membership of each item.

5. This research programme

One of the central aims of the research programme described in this thesis was to develop a research methodology consistent with the theoretically-motivated methodological guidelines discussed above. Accordingly, we designed a computerised experimental task with recognisable slot-machine features but also some novel features that would make findings more generalisable to other gambling tasks. In addition, we developed a method for measuring the illusions of primary and secondary control separately using the recommended 'listed actions' approach. The methodology was then applied to re-examining the contentious effects of success-frequency (Paper 1) and success-slope (Paper 2). The investigation of success-slope effects was also expected to provide a partial test of the theoretical explanation underpinning the methodology. A finding of greater perceived control following an increasing success rate (ascending success-slope) would support the explanation's hypothesis that people engage in problem-solving and trial-and-error learning in gambling contexts.



A third paper tested the explanation's other hypothesis, the hypothesis that the illusion of control has two variants: the illusion of primary control, driven by the gambler's fallacy, and the illusion of secondary control, driven by abstract beliefs about supernatural agents. The test involved the factor-analysis of a survey of erroneous gambling-related beliefs. Figure 1.1 summarises the relationship between the literature on factors influencing the illusion of control, our explanation of the psychological processes giving rise to these findings, and the present research programme.

Figure 1.1. The present research programme in the context of findings on factors influencing the illusion of control

CHAPTER 2: Exegesis

Chapter 1 reviewed existing findings on the illusion of control, focusing largely on factors that are thought to influence the strength of the illusion. Since some of the investigated factors have been shown to exert influence in only a handful of studies, further studies are needed in many cases. In particular need of replication are studies identifying increases in the strength of the illusion with increasing success-frequency and a descending success-slope. Not only are more studies needed to confirm these findings, but success-frequency and success-slope both have an effect on the remembered number of successes, a phenomenon different from perceived control yet typically measured as a proxy for perceived control in studies of all potential influencing factors. Notably, the influence of choice and physical involvement and need for the outcome has been confirmed in a substantial number of studies. In the later parts of Chapter 1, these findings were used as a basis for making hypotheses about the psychological processes underlying the illusion of control. It was proposed that (a) people very likely adopt a problem-solving orientation when gambling, and (b) that the illusion of control very likely comprises two variants: one in which problem-solving is driven by beliefs about supernatural forces such as luck (the illusion of secondary control) and another in which problem solutions are informed by other prior beliefs, including expectations about the sequencing of outcomes in line with the gambler's fallacy (the illusion of primary control). This explanation of the psychological processes underlying the illusion of control is a source of methodological guidelines for replicating the effects of any identified influence. For example, it implies that the illusions of primary and secondary control should be measured separately.

This exegesis begins with an outline of an experimental procedure developed to meet the aforementioned methodological guidelines (Section 1). As the subsequent sections describe, the procedure was then applied in investigating the effects of success-frequency (Paper 1) and success-slope (Paper 2). Paper 2 served the additional purpose of testing the psychological-process explanation's first hypothesis that people adopt a problem-solving orientation when gambling. The third paper, described in Section 4, concerned itself with finding evidence for the explanation's other hypothesis that the illusion of control has two variants reflecting two different abstract belief structures – the gambler's fallacy and beliefs about supernatural agents and forces. As recommended in Chapter 1, the test involved administering a survey about erroneous gambling-related beliefs and then analysing relationships between types of items within that survey. Two broader constructs corresponding to the illusions of primary and secondary control were expected to emerge, with items reflecting the gambler's fallacy and beliefs in supernatural phenomena, respectively. The final section of this exegesis (Section 5) highlights minor theoretical and terminological discontinuities across papers.

1. The theoretically-motivated methodology of Papers 1 and 2

The explanation of the illusion of control outlined in Chapter 1 offers three methodological guidelines for investigating influences on the illusion of control. The first is that the hypothesised influence should be manipulated within a recognisable gambling task, since task instructions accompanying novel tasks can severely limit problem-solving and the extent to which problem-solving might be informed by the gambler's fallacy and beliefs in supernatural forces. The second methodological guideline is that the illusions of primary and secondary control should be measured separately in any self-report-based measures of perceived control. The explanation's third methodological implication also relates to the measurement of perceived control. It is the recommendation that the measure consist of multiple items, each enquiring about the effectiveness of a particular action possible within the gambling task. This section describes an experimental task, perceived control measure and experimental procedure designed to accommodate these methodological constraints.

1.1. Experimental task: recognisable with novel elements

A computerised experimental task was designed to be recognisable as a slot-machine-type game. Slot machine gaming involves betting a certain number of 'credits' on the possibility that some spinning card reels will produce a line of identical card faces once they stop. Players have the option of adjusting the number of lines they bet on, while also receiving free spins for certain symbol combinations. Some machines also feature 'bonus games', which offer players additional choices, with free spins and jackpots as rewards. For example, in a bonus game on the *Queen of the Nile* machine, the participant can double any win by guessing the colour of a card. The win can be quadrupled by guessing the card's suit (Williamson & Walker, 2000).

In the designed experimental task, each trial involved placing a bet on a pictured soccer player scoring from a free kick, with an animation showing whether the kick resulted in a goal or a miss. Upon confirmation of the outcome and adjustment of the credit count, the participant commenced the next trial. Figure 2.1 illustrates the first trial of the game, showing the game's interface on a series of 'screens'. On this first trial, the participant was required to choose the identity of the kicking player from four possible 'player profiles' (Screen 1). This choice (which could be changed at any time), and the kick direction choices that were compulsory in each trial (Screen 3) resembled the choices required in slot-machine bonus games. Another respect in which the task resembled a slot machine is that participants had the option of betting on the results of multiple trials, betting on the player scoring once in the next two trials, for example (Screen 2). The analogous feature in slot-machine gambling is being able to bet on varying numbers of lines. Repeated sounds of applause (accompanying every goal and 'welcoming' the new player onto the field after a player profile change) were designed to mirror the sounds heard during slot machine play. Furthermore, slot machines are designed to feature high rates of 'near wins' – situations where only one reel has a different card face from the others. Correspondingly, in this task, the animations of the kick's result were designed in such a way that outcomes involving a miss were more often close misses saved by the goalkeeper than far misses falling outside the goalposts. In a final point of correspondence, outcomes were randomly determined, with bet and win-amounts for each betting option being calibrated to provide a long-term return rate of -10%, the return rate on South Australian slot machines. That is, for any bet participants could place, the win-amount was 10% less than it should have been if the game were completely fair.

While being analogous to slot machine play in many ways, the task was partially novel in that it did not literally feature spinning card reels. The novelty enabled any problem-solving engaged in during the task to be more independent of beliefs formed during prior experiences with slot-machine gambling. The results were, therefore, more generalisable to other gambling tasks.

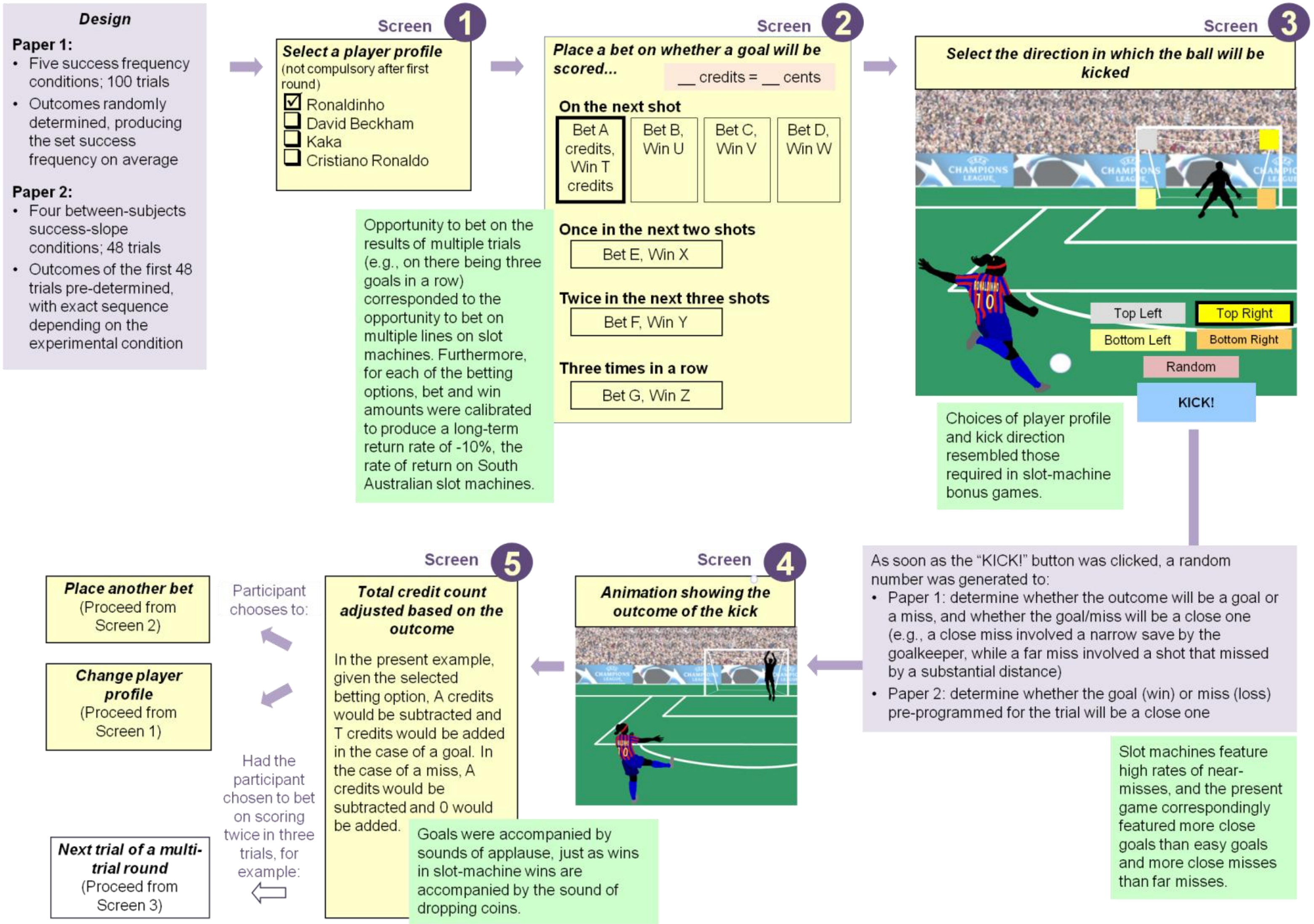


Figure 2.1. The first trial of the experimental task

1.2. Measure of illusory primary and secondary control

As outlined in Chapter 1, it follows from the developed explanation of the illusion of control that any questions about perceived control administered at the end of the experimental session should (a) enquire about the illusions of primary and secondary control separately, and (b) provide a list of possible action alternatives, enquiring about the effectiveness of each one. To meet these constraints, a list of possible actions in the experimental task was compiled, and participants' ratings of the actions' effectiveness were factor-analysed to determine whether pooled ratings for primary-control-type actions could be obtained separately from pooled ratings for secondary-control-type actions. In other words, participants' ratings of the effectiveness of various action alternatives served as observed variables in a factor analysis aimed at extracting measures of illusory primary and secondary control. This sub-section describes the list of actions and the factor analysis procedure.

The list of actions comprising the post-experimental perceived control measure consisted of references to strategies and practice, references to interaction with the physical features of the experimental task (computer, player profiles, the goalkeeper etc.), and references to luck and deservingness, drawn from interviews with people who gamble regularly (Henslin, 1967; Keren & Wagenaar, 1985; King, 1990). The exact statements presented to participants are listed below. Participants rated each statement on a scale from 0 to 10 to indicate whether they considered it a description of the reason for successes obtained in the task:

I got better with practice.
I developed a logical strategy for playing the game.
Experience at playing computer games
My skill in playing the game
I learned how to predict the movements of the goalkeeper.
My knowledge of soccer
The player(s) I chose
The kick directions I chose
The bet options I chose
I deserved to win.
I took advantage of moments when my luck was good.
I've always been a lucky kind of person.

A certain lucky way of playing just seemed to work for me.
I knew how to make luck go my way.
It was all chance.

Statements relating to strategies and physical game features (Statements 1-9[4]) were intended to provide an opportunity for expressing the illusion of primary control, while statements about luck and deservingness (Statements 10-14) were designed to gauge the illusion of secondary control. The objectively accurate statement “It was all chance” (15) was included to indicate to participants that they were not necessarily expected to account for successes in terms of personal control.

The factor analysis aimed at creating dependent measures of illusory primary and secondary control was preceded by a screening procedure. As part of this, each statement was examined for whether it received a disproportionately high number of zero ratings compared to other statements. In both Paper 1 and Paper 2, no statements were problematic in this regard. The second part of the screening involved examining each statement for whether non-zero ratings on it correlated with responses to other statements. This part of the procedure was directed at identifying invalid (i.e., poorly worded) statements while taking into account the high number of ‘zero’ ratings provided by any participants who agreed with only a small selection of the statements. Statements whose non-zero ratings correlated with responses on few other statements were excluded from subsequent factor analysis, although, in Paper 1, the ‘It was all chance’ statement was retained despite the fact that it fulfilled these exclusion criteria. This oversight did not occur in Paper 2 and, for Paper 1, was corrected in Appendix 3B (see Section 5.1 for further comments). For the retained statements, exploratory factor analysis involved using the mineigen, scree test and parallel analysis methods to determine how many factors to extract (e.g., Hayton, Allen & Scarpello, 2004). Broad support for a two-factor solution reflecting the illusions of primary control and secondary control was obtained in both papers, such that statements 1-4 (about practice, strategy use, computer games and skill) consistently loaded on one factor while statements 10-14 (about luck) loaded on another. For statements defining each factor, ratings were pooled to create measures of illusory primary and secondary control.

[4] Statements 8 and 9 were only added to the set in Paper 2.

1.3. Experimental procedure

The developed task and measure constrained the experimental procedure in a number of ways. Firstly, to ensure that the partially novel experimental task was recognisable as a game of chance, task instructions had to emphasise that the task operated on the same principles as a slot machine (for exact wording, see Appendix 4A.2).

Secondly, given the task's slot-machine elements and soccer theme, it was necessary to control for existing beliefs about gambling and soccer when examining perceived control across experimental conditions. These beliefs were measured in a pre-experimental questionnaire, using the Drake Beliefs About Chance Inventory (DBC; Wood & Clapham, 2005) and a five-point soccer interest scale (see Appendix 4A.1). With scores on these measures as covariates in the main analyses, it was possible to account for variance in perceived control due to, for example, strong prior beliefs in the uncontrollability of all games of chance – beliefs that would lower ratings on all items of the perceived control measure. By the same token, it was possible to at least partially account for variance due to knowledge that the top left would have been the optimal kicking direction in a real soccer game where the goalkeeper and kicking player were in the pictured starting positions.

A further requirement for the experimental procedure was that participants were adequately debriefed regarding the mechanisms governing slot-machine operation – namely, the random generation of outcomes and negative return to players. This information had to be conveyed to ensure that experiencing the task's novel soccer features did not lead participants to expect that, in slot-machine gambling, there exists the equivalent of choosing the 'correct' player profile, 'correct' kick direction, or both. The debriefing information provided to participants is detailed in Appendix 4E.

2. Success-frequency: Paper 1

The first paper applied the described methodology in investigating whether success-frequency is indeed an influence on the illusion of control. Existing findings that identify success-frequency as an influencing factor are problematic in two respects. First, there is a possibility that the measures of inferred control used in the contributing studies have, in fact, gauged remembered success-frequency. Second, from the point of view of a presented explanation of the illusion of control, the studies' novel experimental task format and 'contingency-detection' instructional set restricted the extent to which beliefs responsible for the illusion of control (supernatural beliefs and the gambler's fallacy) could be brought to bear on problem-solving. The experimental task, perceived-control measure and experimental procedure described above overcome both of these past methodological limitations and it was, therefore, necessary to examine whether the success-frequency effect holds when they are applied.

Participants (*N* = 96) played the soccer-themed gambling game under one of five success-frequency conditions (one goal per 16 trials, 8 trials, 4 trials, 3 trials or 2 trials). The playing session lasted for 100 trials, and, upon its conclusion, perceived control was assessed using the newly-developed measure. The study also included a perceived control measure similar to the one used in previous studies of success-frequency: "Using the scale below, how would you describe your level of control over the game's outcomes? [0 = Non-existent, 3 = Moderate, 6 = Complete]".

3. Success-slope: Paper 2

The newly-developed measure and methodology were next applied in re-examining the effects of success-slope, which refers to win rate over time within a playing session. The illusion of control has typically been found to be strongest following a descending slope (i.e., early successes followed by few successes), but, as with findings relating to the influence of success-frequency, this finding could reflect the confounding of perceived control with remembered success-frequency. In three of the four studies that produced the finding, the chief dependent measures gauged remembered success-frequency (e.g., "How many successes did you have on the 30 trials?"). The finding, thus, potentially reflects a memory-based 'primacy effect' rather than success-slope-driven variation in perceived control. A fourth study (Burger, 1986) did include a more direct measure of perceived control, but another study that did the same (Matute, 1995) observed higher perceived control following an ascending success-slope (i.e., a concentration of successes at the session's end).

In investigating the success-slope effect using the newly-developed methodology, the main aim was to determine whether the effect exists and, if so, what success-slopes produce the strongest illusory control inferences. An additional aim was to examine the effect of success-slope on estimates of remembered success-frequency. Another, implicit, aim of the paper related to the psychological-process explanation developed in Chapter 1. The aim was to test the explanation's hypothesis that the illusion of control can be considered a by-product of the problem-solving people engage in when gambling. The hypothesis would be supported if the 'ascending' condition is found to produce higher perceived control. In other words, a finding of this nature would suggest that participants approached the gambling task as one in which the means to obtaining wins could be discovered through learning, which is a component of problem-solving (Anderson, 1993).

Participants (N = 334) experienced 48 trials of the soccer-themed task under one of four success-slope conditions: descending (early successes), ascending (late successes), flat (evenly-distributed successes) and U-shaped (early and late successes). Dependent measures, administered in a post-session questionnaire, consisted of the primary and secondary illusory control indices produced by factor-analysing the newly-developed measure of perceived control. Also included were two success-frequency estimates analogous to those featured in past success-slope studies: "What percentage of the shots you kicked resulted in goals?" and "If you were allowed to kick another 100 shots, on how many of those do you think you would score a goal?"

4. Two variants of the illusion of control: Paper 3

Following the application of a theoretically-driven methodology to the re-examination of two long-standing problems in the literature, the underlying theory – the psychological-process explanation presented in Chapter 1 – was subjected to further testing. The test focused on the explanation's proposal that there are two variants of the illusion of control – a primary, emerging from the gambler's fallacy and other beliefs about non-supernatural phenomena, and a secondary, emerging from abstract beliefs about supernatural agents and forces. The raw data consisted of responses to a survey about erroneous gambling-related beliefs. Survey items were statements of erroneous beliefs and participants were required to express their degree of agreement or disagreement with each one. Since the items were based on interviews with people who gamble regularly, it was assumed that they represented illusions of control – problem-solving solutions entertained by people in gambling settings. The proposal being tested was, thus, whether the items would form two broader categories reflecting the relevant abstract beliefs (supernatural beliefs and the gambler's fallacy).

The study's first step was the compilation of a survey broad enough to cover most of the problem-solving solutions people have reported in gambling settings. It was also crucial that the survey was not too focused on particular types of solutions (e.g., the illusion of primary control only). To achieve these aims, survey items were drawn from both existing surveys and qualitative descriptions of erroneous gambling-related beliefs. Over 10 surveys of gambling-related beliefs have been designed and validated, and the aim was to borrow items from the surveys in such a way that as many surveys as possible could be included in their entirety without there being identical items. The inclusion of entire surveys ensured that no particular beliefs were the focus of the survey, while the inclusion of multiple existing surveys ensured that a broad range of beliefs was represented. Additional items were written to represent beliefs documented in qualitative studies but missed by existing surveys. A survey of 100 items was thus compiled, featuring full versions of the Drake Beliefs About Chance Inventory (Wood & Clapham, 2005), the Gambling Beliefs Questionnaire (Steenbergh et al., 2002) and the Predictive Control Scale of the Gambling-Related Cognitions Survey (Raylu & Oei, 2004). Notably, items were adjusted to refer specifically to slot-machine gambling, so that there was no risk of participants misinterpreting some of the beliefs expressed by items as being correct for partially skilled gambling games (e.g., Bridge).

The next step, following the survey's administration to 329 participants, consisted of the removal of items that correlated only weakly with other items. Specifically, items that correlated with 60 or more other items at a magnitude of less than .3 were removed. This filtering process ensured that the survey did not contain references to beliefs held only by select individuals, beliefs not related to slot-machine gambling, and beliefs not related to gambling more generally.

As a final step, relationships between retained items were analysed to test the prediction that there would be two broad types, one reflecting supernatural beliefs, and the other reflecting the gambler's fallacy and any other beliefs. Broader item types have, in some surveys, been uncovered through exploratory factor analysis (Jefferson & Nicki, 2003; Raylu & Oei, 2004; Steenbergh et al., 2002; Wood & Clapham, 2005). However, the exploratory approach is often poorly suited to hypothesis testing when some items load on more than one factor (MacCallum, Widaman, Zhang & Hong, 1999), and, in this survey, items expressing the belief that luck is cyclical were expected to do so. Examples of the items are "Wins are more likely to occur on a hot machine" and "A series of losses is a sign that good luck is about to set in". Within these beliefs, the notion of cyclical successes appears to reflect the gambler's fallacy while the notion of a force called 'luck' appears to reflect broader beliefs in supernatural agents. Thus, instead of an exploratory factor analysis, a confirmatory factor analysis (CFA) was performed. This approach allows the researcher to identify cross-loading items *a priori*, but it is feasible only with a small number of items or scales (Floyd & Widaman, 1995). More specifically, CFA involves specifying one or more latent factors and the one or more items or scales that load on them. The specifications represent a model, which is assessed for how well it accounts for covariances between the items or scales (e.g., Kline, 2010).

In specifying the CFA model, survey items were grouped into scales based on theoretical considerations. One scale, for example, consisted of items expressing the belief that luck is cyclical. Scores on this scale (the average of the constituent items) were modelled as loading on both postulated latent factors – the illusion of primary control and the illusion of secondary control. The illusion of primary control was additionally defined by scales referring to the negative recency of chance outcomes, to systems of play, and to the value of persistence. Beliefs in negative recency clearly stem from the gambler's fallacy, and the other two belief types also potentially reflect the fallacy in that a 'system' of play can refer to a strategy based on expectations of negative recency and persistence in the face of losses is a valid slot-machine strategy if a loss on the next round is believed to be less likely with every experienced loss. The illusion of secondary control within the CFA model was, in addition to the 'cyclical luck' scale, defined by scales capturing beliefs in (a) the omniscience and power of supernatural agents such as luck and fate, and (b) the effectiveness of ritual appeals to these agents. Atran and Norenzayan (2004) drew a distinction between these two belief types in their original article on the abstract structure of beliefs about the supernatural. The model's fit to the scale covariance matrix was examined.

5. Minor inconsistencies across papers: theory and terminology

The exegesis has, so far, related the papers' research questions and methodology to the explanation of the psychological processes underlying the illusion of control presented in Chapter 1. The explanation was, indeed, the driving force behind the research programme, but it was not fully formed at the time Paper 1 was written, so the paper introduces concepts not mentioned elsewhere. This section describes the theoretical inconsistencies in more detail before highlighting some minor terminological inconsistencies.

5.1. Theory

Paper 1 (on the effects of success-frequency) differs from the other papers in that its guiding theoretical framework did not involve defining the illusion of control as a by-product of a problem-solving process. Instead, the illusion was speculated to be a by-product of beliefs about control, with different beliefs being activated by different types of post-experimental questions. More specifically, it was speculated that asking about the effectiveness of various listed actions using the newly-developed measure activated 'means-ends' beliefs, while asking about perceived control directly, as per the traditional measure, activated 'agent-ends' beliefs (Skinner, Chapman & Baltes, 1988).

The theoretical framework of Paper 1 also differed from the theoretical frameworks of the other papers in that it did not make clear hypotheses regarding the source of the distinction between the illusions of primary and secondary control. That is, while the psychological explanation in Chapter 1 attributes the distinction to the existence of different types of abstract beliefs (supernatural, gambler's fallacy, etc.), this possibility was not considered at the time Paper 1 was written, and the paper is fittingly vague on the issue, attributing the distinction to a difference in "contexts governing the acquisition" of different types of 'means-ends' beliefs (p. 66).

A repercussion of the paper's general lack of clarity on the nature of the illusion of control is that, following a factor analysis of responses to the newly-developed dependent measure, 'disregard of the role of chance' was labelled a third possible variant of the illusion of control, even though the preliminary screening procedure (see Section 1.2) suggested that the relevant item ("It was all chance") be excluded from the factor analysis. The item was retained because of its significance as the measure's "single objectively correct statement" (p. __). In reminding participants that the soccer task was a game of chance rather than skill, the item did serve a methodological function. However, due to the absence of a fully-formed theoretical framework (i.e., lack of recognition of the role of problem-solving and abstract beliefs), the item's methodological function was not distinguished from its theoretical significance. Appendix 3B shows that the paper's findings regarding the effects of success-frequency were not affected by this error in analysing the dependent measure.

5.2. Terminology

One of the slight terminological differences across papers is that Paper 1 refers to "poker machines" instead of slot machines. The paper was written for a conference in Australia, where "poker machine" is a well-recognised term.

Another noteworthy point is that, while Paper 1 refers exclusively to "perceived" control, Papers 2 and 3 also make references to "inferred" control. Technically, the latter term is more correct, especially with respect to the explanation of the illusion of control presented in Chapter 1. Inference refers to the drawing of a logical conclusion from information, and problem-solving, one of the psychological processes proposed to underlie the illusion of control, involves the drawing of conclusions from environmental cues and background beliefs.

CHAPTER 3: Paper 1

The illusion of control: structure, measurement and dependence on reinforcement frequency in the context of a laboratory gambling task

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Abstract: We present a new experimental method for studying the illusion of control in a gambling context, along with a new multi-item measure of the degree of perceived control. Responses to the measure were found to reflect a distinction between primary and secondary control – a distinction not recognised by traditional single-item measures. Furthermore, responses to the new measure were, in contrast to ratings on a concurrently administered traditional measure, found to be completely independent of the experienced reinforcement frequency. This finding highlights the purity of the newly-developed measure and calls into question the status of reinforcement frequency as a fundamental determinant of the degree of illusorily perceived control.

Introduction

In a seminal exposition of the cognitive theory of gambling, Walker (1992b) argues that most patterns of irrational thinking among gamblers essentially consist of the illusion that "one has more control over the outcome than is in fact the case" (pp. 139-140) or the overestimation of one's chances of winning independently of any actions taken. In the context of poker machine gaming, roulette and dice – gambling forms where outcomes are completely random – any perceived control is necessarily illusory. Nevertheless, regular gamblers report the use of a wide variety of strategies (e.g., changing machines in a systematic fashion; see Joukhador, Blaszczynski &

Maccallum, 2004; Livingstone, Wooley & Borrell, 2006) that make sense only on the assumption that the player can exert control over outcomes based on knowledge of the game. While many of these strategies can be termed products of illusorily perceived "primary" control because they rely on the idea that it is the player who has control, players also report employing "secondary" control strategies, in which they seek to achieve favourable outcomes by aligning themselves with influential higher or external forces (Rothbaum, Weisz & Snyder, 1982), such as luck (Keren & Wagenaar, 1985; King, 1990; Ocean & Smith, 1993; Duong & Ohtsuka, 2000), magic (Felson & Gmelch, 1979; Henslin, 1967), or justice (King, 1990). Although conceptually distinct, primary and secondary strategies tend to blend together: for instance, in Keren and Wagenaar's (1985) study, many of the interviewed regular blackjack players spoke of 'changing-up' play, not as a mathematically appropriate strategy, but, rather, as the necessary response to a period of bad luck. Thus, a very broad range of gambling behaviours can be described as products of an illusion of primary or secondary control over objectively random outcomes.

The basic experimental paradigm for studying the determinants of the illusion of control dates back to Langer (1975), and involves exposing people to uncontrollable events without explicitly indicating that the events in question are uncontrollable. While various elaborations on the design have yielded considerable insight into the illusion of control (e.g., Alloy & Abramson, 1979; Matute 1994, 1995), most work since Langer has employed very minimalist tasks that are often somewhat abstracted from the gambling context (e.g., involving the judgement of the degree of contingency between a button press and the onset of a light). Although a minimalist approach is often helpful from a scientific perspective, there is a noticeable difference in "feel" between a casino and a psychology experiment, which may limit the generalisability of the findings. Additionally, there is the issue of instructional demand effects. The fact that minimalist tasks involve only a few abstract stimuli leads to the use of instructions that either reveal the research aim (e.g., Alloy & Abramson, 1979), or deliberately conceal it by directing participants to focus simply on obtaining the target outcome as often as possible (e.g., Matute, 1994). In the former case, participants proceed to carry out the somewhat unnatural task of monitoring their control levels without expressly seeking reinforcement. In the latter case, participants could come to expect that, since they have been given the task of maximising reinforcement levels, there must be a systematic way of obtaining the target outcome.

It is in part due to such considerations that many studies have featured experimental tasks based on actual gambling activities, such as poker machines (e.g., Ladouceur & Sevigny, 2005), roulette (e.g., Dixon, 2000), and lotteries (e.g., Langer, 1975; Wohl & Enzle, 2002). However, the use of existing gambling game formats can cause participants to base their post-experimental ratings of control not only on what they immediately experienced during the experiment, but also on their existing beliefs about that form of gambling. A partial solution to this problem is to gauge relevant beliefs at the start of the experiment. Recently-developed gambling-related belief questionnaires (Jefferson & Nicki, 2003; Joukhador, Blaszczynski & Maccallum, 2003; Raylu & Oei, 2004; Steenbergh, Meyers, May & Whelan, 2002; Wood & Clapham, 2005) could be employed for this purpose. However, such self-report tasks may not capture many of the elements of decision-making that emerge when people are asked to make judgements in real time. Accordingly, there would appear to be a need to develop tasks that capture the important elements of gambling decision-making, but which are more immune to contamination from variations in previous gambling experience as well as instructional sets.

Apart from the appropriate design of these experiments, there is the issue of how the strength of the illusion of control might be determined. Some researchers have drawn inferences regarding the illusion of control based solely on participants' average bet amounts (e.g., Burger & Schnerring, 1982; Gilovich & Douglas, 1986), or estimates of the number of reinforcements expected in future rounds of the task (e.g., Budescu & Bruderman, 1995; Langer, 1975). However, these measures necessarily equate the illusion of control to the expectation or perception of success. As noted by Walker (1992b) in the quoted passage, confidence and control are not equivalent.

Many other studies have adopted a simpler approach in asking people to rate the degree of perceived control over task outcomes on a visual analogue scale. Due to their brevity, measures of this kind invariably treat control as a unitary construct, making no distinction between primary and secondary facets. This is not a problem if people do not seek secondary control or fail to distinguish between the two types of control processes. However, should either of these conditions not hold, people may find a single question about "control" somewhat confusing. Another concern is that there is some evidence that rating scales of this kind conflate perceived success-frequency with control. Jenkins and Ward (1965) found that responses to questions containing the word "control" were strongly positively related to reinforcement frequency, while responses to less transparent questions about contingency were not influenced by reinforcement frequency at all. Jenkins and Ward subsequently argued that people actually interpret "control" to mean 'attainment of the target outcome'. Accordingly, in answer to questions that refer explicitly to the degree of perceived "control", people may not be giving a rating of perceived contingency at all.

Despite this, most studies of the relationship between success-frequency and the illusion of control continue to employ explicitly worded measures as the sole measures of perceived control. Thus, although higher reinforcement frequencies are consistently found to produce higher perceived "control" (Alloy & Abramson, 1979; Tennen & Sharp, 1983), it is not clear whether reinforcement frequency is a fundamental determinant of the illusion of control (Thompson et al., 2007), or if the trend is an artifact of the wording of the questions. To address this issue, a more systematic approach is required.

In view of these considerations, the aims of this paper are fourfold. First, we describe an experimental task that was designed to achieve a compromise between the incorporation of novel stimuli and the preservation of a gambling game format. Also described is an experimental procedure geared at minimising instructional demand effects, and, in fact, quantifying some of those effects through the pre-experimental assessment of gambling-related beliefs. Second, we present a perceived control measure that we developed with a view to preserving the primary-secondary distinction and avoiding the potential confusion with reinforcement frequency that arises from explicit references to 'control'. Our third aim was to use the newly-developed measure in determining whether people do in fact distinguish between primary and secondary control processes and, by implication, whether there are grounds for deploying a perceived control measure that conceptualises control as a multi-faceted construct rather than the general unitary construct gauged by traditional measures. Finally, we employ the new task, the new measure and a traditional explicitly worded measure in testing Jenkins and Ward's conjecture regarding the differential effects of reinforcement frequency on ratings of perceived “control” and responses to more subtle questions about perceived contingency. We subsequently seek to make a more general statement regarding the relationship between reinforcement frequency and the illusion of control.

Method

Participants

One hundred students from the University of Adelaide participated in the study, but three participants who responded identically to all the items of the newly-developed measure of perceived control were excluded. A technical error resulted in the loss of another person’s pre-experimental-questionnaire data, so some of the reported analyses contain only 96 data points, as will be made clear in the relevant tables and figures.

Materials and procedure

The overall design of the experiment was as follows. Upon completing a pre-experimental questionnaire concerned with gambling-related beliefs, each participant played 100 compulsory rounds (i.e., shots) of the gambling task described later. This was done under one of five conditions, in which the average reinforcement frequency ranged from one win in every 16 rounds to one in every two. Participants were not told how many rounds they would be playing, but were informed that they could terminate the game and cash out on remaining credit at any point after completing an impressions-of-the-game questionnaire. This questionnaire appeared automatically after 100 rounds of play.

The pre-experimental questionnaire contained the Drake Beliefs About Chance (DBC) Inventory (Wood & Clapham, 2005), which required participants to rate their degree of agreement with 22 erroneous statements about the nature of gambling (e.g., “Wins are more likely to occur on a hot machine”, “I can improve my chances of winning by performing special rituals”). Statements that referred to gambling in general were adapted to refer to the outcomes of poker machines, roulette and dice games. A DBC total score was calculated by summing the provided ratings.

The experimental gambling task had a soccer theme. In each round, participants bet on a player pictured on the screen scoring (as opposed to missing) a goal from a free kick. Hence, each round involved the selection of a bet amount and bet structure from the seven options depicted in the Screen 2 pane of Figure 3.1. Each round also required the selection of a kick direction (Screen 3). Player profile choices (Screen 1) could be changed at any point but were not compulsory after the first round. Despite the abundance of play-related choices, the outcome of each kick was, as on poker machines, determined by a random number generator and the bet amounts and associated win-amounts were calibrated to produce a negative long-term winning expectancy (see Appendix 3A[5]). The experiment was introduced to participants as an investigation of emotional responses to a new, sports-themed gambling game that "operates on the same principles as a poker machine". In referring to the trial of a new game, this instructional set encouraged participants to 'just play' without concerning themselves with the degree of control inherent in the task. The reference to poker machines served to guard against participants automatically assuming that the new sports-themed game possessed a video-game-like skill component.

The third element of the experiment was the "impressions of the game" questionnaire. Placed amid filler items regarding emotional responses to the game, this questionnaire contained two questions about perceptions of control over game outcomes. One of the questions (Measure A in Figure 3.2) followed the traditionally employed single-item rating-scale-based form. The new measure (Measure B in Figure 3.2) encompassed 13 randomly-ordered items, presented in the form of to-be-evaluated causal explanations for wins. Each explanation implicated a phenomenon associated either with primary control or secondary control. The objectively accurate account, "It was all chance", was also among the items.

[5] This appendix and Appendix 3B were not included in the published version of this paper.

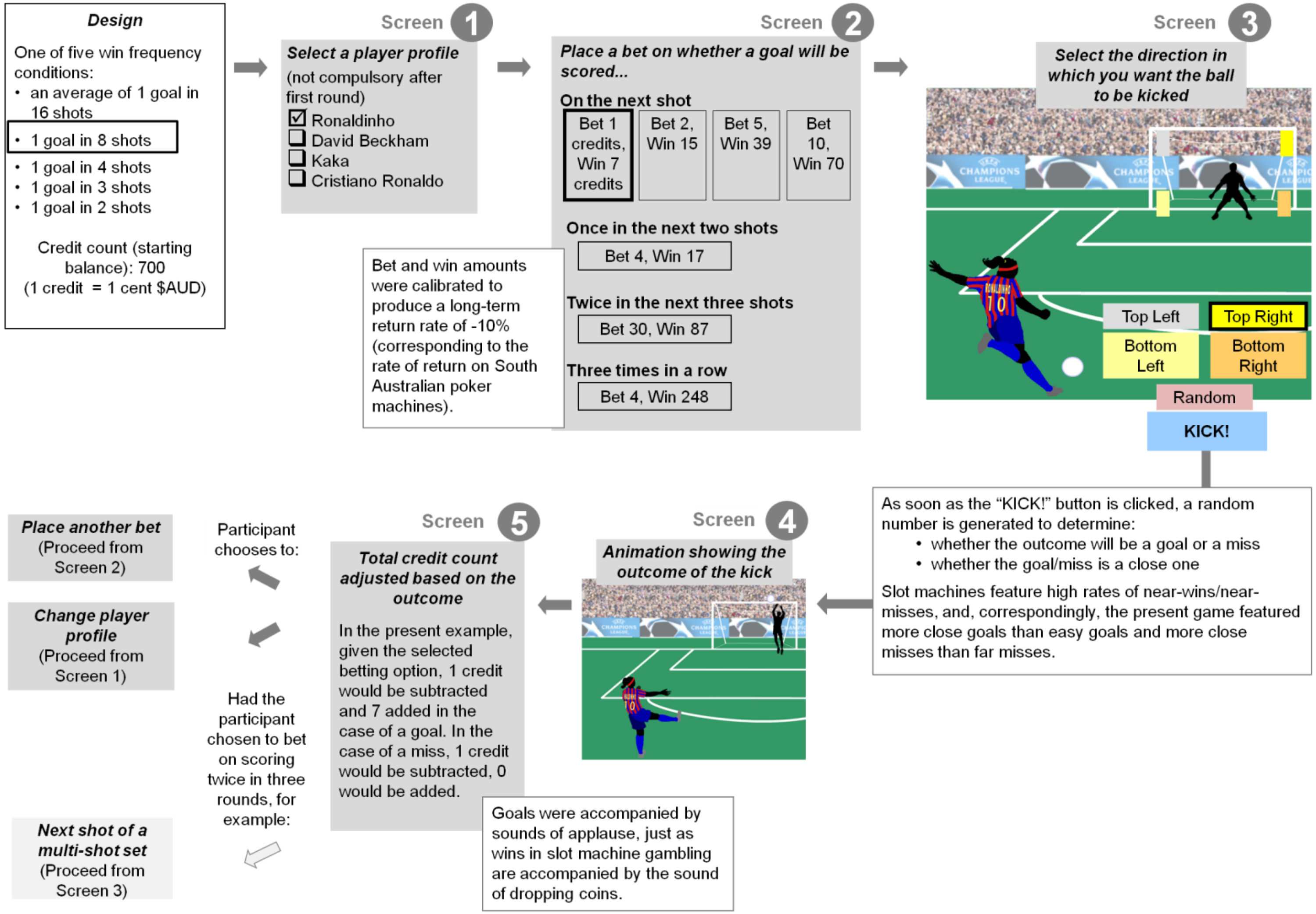
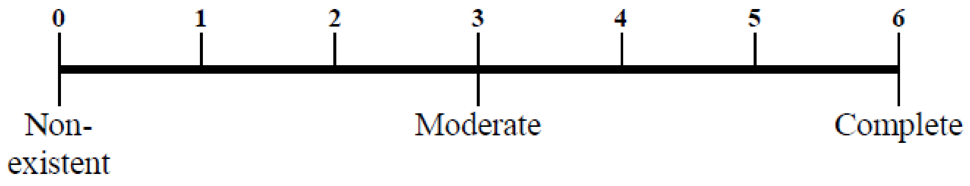


Figure 3.1. The first round of the experimental task

Measure A (Traditional measure)

Using the scale below, how would you describe your level of control over the game's outcomes?



Measure B (Newly-developed measure)

When thinking about your wins/goals, to what extent would you use each of the following statements to describe how they came about? Rate each of the statements using a number from 0 to 10.

As a guide, give a rating of 0 if you think that the phenomenon described by the statement was not one of the reasons, a rating of 5 if you think the phenomenon was a moderately important reason, and a rating of 10 if you think that the phenomenon was one of the most important reasons.

Phenomena associated with **perceived primary control**:

1. My skill in playing the game
2. I developed a logical strategy for playing the game
3. I got better with practice
4. My knowledge of soccer
5. Experience at playing computer games
6. The player(s) I chose
7. I learned how to predict the movements of the goalkeeper

Phenomena associated with **perceived secondary control**:

8. I took advantage of moments when my luck was good
9. A certain lucky way of playing just seemed to work for me
10. I knew how to make my luck turn good
11. I've always been a lucky kind of person
12. I deserved to win

Objectively correct statement:

13. It was all chance

Figure 3.2. The two featured measures of the degree of illusorily perceived control

Results

As an initial calibration check, we looked at whether responses to the various measures showed sufficient variability. For the gambling-related beliefs measure, the observed mean of 59.7 was slightly higher than those observed among in-treatment gamblers and members of the general community in the DBC Inventory's original validation study, but the standard deviation of 15.63 was in close agreement (Wood & Clapham, 2005; Gamblers: M = 48.4, SD = 15.84; Community: M = 44.9, SD = 14.08). Responses to the traditional rating scale (Measure A in Figure 3.2) of perceived control also showed a reasonable degree of variability: 30 participants stated that they had no control, but a similar number (29) perceived a level of control that was moderate or higher (i.e., gave ratings of 3 to 6).

The distribution of responses to the newly-developed perceived control measure is summarised in Table 3.1. Most statements, including the correct "It was all chance" statement, were awarded non-zero ratings by approximately 60% of participants. Only four participants provided ratings of zero on all of the primary- and secondary-control-related statements while awarding maximal ratings to the 'Chance' statement.

Table 3.1. Distribution of responses to the newly-developed measure of the degree of perceived control (N = 97)

Statement referring to:	No. of participants providing an agreement rating of: 0 out of 10	1 to 4 out of 10	5 out of 10	6 or more out of 10
Skill	37	32	10	18
Strategy	23	29	17	28
Practice	36	28	13	20
Soccer knowledge	46	27	10	13
Computer games	40	33	10	14
Player profiles	30	27	19	21
Goal-keeper	38	36	16	7
Lucky moments	30	20	17	30
Lucky play pattern	30	28	20	19
Knowledge of luck	42	37	11	7
Lucky person	33	37	12	15
Deserving to win	40	23	20	14
	10 out of 10	9 to 6 out of 10	5 out of 10	4 or less out of 10
Chance	42	31	12	12

Primary and secondary control: factor analysis

To test the validity of the theoretical distinction between primary and secondary control built into the newly-developed measure a factor analysis of statement rating patterns was conducted. However, following the observation of a relatively large number of zero ratings at baseline (see Table 3.1), we prefaced the factor analysis with a data screening procedure aimed at the identification and removal of statements that correlated with other statements due solely to overlapping (that is, inter-correlating) zero ratings.

Data screening

Starting with the statement that produced the most "zeros" (soccer knowledge), we excluded all participants who provided a zero rating for that statement. If, following that exclusion, the correlations of other statements with that statement became largely non-significant, we deemed the statement to be unsuitable, and removed it from subsequent analysis on the grounds that the zero vs. non-zero distinction must have been responsible for the entirety of the original correlations.

The application of this procedure led to the removal from further analysis of the statements pertaining to soccer knowledge and deservingness. The lack of correlation between these statements and other statements is illustrated in Table 3.2, where the shaded squares in each column denote the correlation coefficients that remained significant among participants who provided ratings greater than zero on the statement specified in the column heading. Non-zero responses to the 'Chance' statement were expected to correlate with responses to a range of different statements, but were discovered to be independent of other responses. The statement was, however, retained for use in subsequent analyses to allow for the possibility that, as the scale's single objectively correct statement, it would form a separate factor altogether. Notably, the second-stage (shaded) correlations revealed a 'perceived primary control' cluster consisting of agreement ratings for statements about skill, strategy, practice and computer game experience. Ratings on the remainder of the statements – statements relating largely to luck – inter-correlated substantially in forming a 'perceived secondary control' cluster. Statements about player profile choices and goalkeeper movement represented a point of overlap between the two clusters, but did not share with the 'perceived primary control' statements the feature of being uncorrelated with most of the other statements. Thus emerged the first traces of a multi-faceted perceived control construct involving a distinction between perceived primary control, perceived secondary control and acknowledgement of the role of chance.

Table 3.2. Spearman correlations between ratings of agreement with the causal explanation statements of the newly-developed measure of the degree of perceived control. Note that the shaded squares are meaningful only in relation to the columns – not rows – of the table. See main text for details.

Statement relating to:	Skill	Strategy	Practice	Computer games	Player choices	Goal-keeper	Lucky moments	Lucky play pattern	Knowledge of luck	Lucky person	Soccer knowledge	Deserving to win	Chance
Skill													
Strategy	.48**												
Practice	.68**	.51**											
Computer games	.59**	.42**	.58**										
Player choices	.56**	.40**	.46**	.42**									
Goal-keeper	.56**	.31**	.52**	.41**	.51**								
Lucky moments	.55**	.33**	.50**	.42**	.62**	.53**							
Lucky play pattern	.49**	.37**	.31**	.31**	.54**	.55**	.51**						
Knowledge of luck	.61**	.36**	.44**	.49**	.58**	.53**	.47**	.58**					
Lucky person	.50**	.24*	.43**	.38**	.45**	.48**	.51**	.59**	.55**				
Soccer knowledge	.46**	.36**	.44**	.59**	.45**	.61**	.51**	.45**	.55**	.46**			
Deserving to win	.43**	.29**	.43**	.46**	.50**	.50**	.49**	.52**	.47**	.57**	.43**		
Chance	-.37**	-.11	-.37**	-.39**	-.22	-.30**	-.18	-.16	-.36**	-.18	-.29**	-.25*	

** Correlation significant at the .01 level (two-tailed, *N* = 97)

* Correlation significant at the .05 level (two-tailed, *N* = 97)

[shaded] Correlation significant at the .01 level (two-tailed, *N* = number of participants who provided a rating other than zero on the statement indicated in the column heading – see Table 1)

[hatched] Statement excluded from analysis due to high number of associated zero ratings and lack of correlation with other statements

[dashed line] Pattern of agreement rating correlations potentially underpinned by the degree of perceived **primary** control

[solid line] Pattern of agreement rating correlations potentially underpinned by the degree of perceived **secondary** control

Factor analysis

Upon ascertaining the factorability of ratings on the retained 11 statements (KMO = .88; Bartlett's test: (χ^2 (55) = 428.82, $p < .001$; initial communalities shown in Table 3.3), we conducted Principal Axis Factoring based on the criterion that a factor should be extracted if it has an eigen value of .7 or above – a value appropriate for small sample sizes (Jolliffe, 1972, 1976). The procedure resulted in the extraction of three factors with initial eigen values of 5.03, 1.26 and 0.99 – all lying above the inflection point of the scree plot. After extraction the factors accounted, respectively, for 42, 7 and 4 percent of total variance in ratings. Table 3.3 shows the factor loadings of the statements following a direct oblimin rotation. The loadings were relatively strong, with the lowest loading (for 'Computer games' on Factor 2) having a magnitude of .48.

Most crucially, the pattern of loadings corresponded to the clustering observed at the data screening stage. Factor 1 corresponded to ‘Perceived secondary control’ in subsuming the four luck-related statements and the more stimulus-specific statements regarding player profile choices and goalkeeper movements. Factor 2 subsumed statements relating to direct – that is, primary – control: ‘Skill’, ‘Strategy’, ‘Practice’ and ‘Computer games’. Factor 3 contained the single ‘Chance’ item (see Appendix 3B for a factor analysis not involving the ‘Chance’ item).

Table 3.3. Initial communalities and factor loadings and communalities produced by a PAF analysis with oblimin rotation for 11 retained statements of the newly-developed measure (N = 97)

Statement referring to:	Initial communality	Factor loadings F1 Secondary control	F2 Primary control	F3 Chance	Communality
Lucky play pattern	.60	.89			.68
Lucky person	.50	.66			.52
Knowledge of luck	.54	.65			.57
Player profiles	.37	.63			.39
Goal-keeper	.51	.57			.63
Lucky moments	.53	.55			.59
Practice	.44		-.82		.46
Skill	.19		-.62		.39
Strategy	.58		-.62		.71
Computer games	.40		-.48		.43
Chance	.38			.60	.45
Cronbach’s alpha of factor score		.856	.799		
Correlation of factor with		F2: -.59	F3: .33	F1: -.25	

Note: Factor loadings <.4 are suppressed

Overall, then, the analysis of intercorrelations between components of the newly-developed measure of the illusion of control suggested that the illusion can be conceived of in terms of three facets: perceived primary control, perceived secondary control, and acknowledgement of the role of chance. This, in turn, highlights the advantages of the newly-developed measure over any measure of perceived control that refers to ‘control’ as though it were a unitary construct.

Reinforcement frequency and perceived control

In further assessing the advantages of the newly-developed measure over the traditional measure, we set out to determine whether, in line with Jenkins and Ward’s (1965) findings, the newly-developed measure would, by virtue of not referring explicitly to control, attract responses less reflective of the experienced win frequency. However, since participants were, from the outset, informed that the experimental task was designed to operate on the same principles as a poker machine, we expected that responses to both measures would additionally depend on participants’ individual beliefs regarding the nature of poker machine gambling. Thus, we conducted hierarchical regression analyses to assess the degree to which indices of the three facets underlying the new measure and, by contrast, responses to the traditional measure, could be attributed to variability in the number of experienced wins over and above the effects of variability in DBC scores. The indices of the three facets of illusorily perceived control were factor scores calculated using the regression method. The Cronbach’s-alpha levels associated with the perceived primary control and perceived secondary control factor scores are detailed in Table 3.3.

For each of the four regression analyses, the DBC score was entered into the regression at Step 1, followed, at Step 2, by the index of win frequency – the percentage of compulsory rounds that resulted in wins. The results are summarised in Figure 3.3[6].

As the adjusted R^2 values associated with Step 1 of each analysis indicate, existing gambling-related beliefs accounted for a substantial amount of variance in all the indices of perceived control. However, the traditional measure was the only measure of perceived control to also be influenced by the experienced win frequency (adj R^2 at Step 1 = .23; adj R^2 at Step 2 = .34).

Consistently with Jenkins and Ward’s observations, then, these results imply that the factor scores derived from the newly-developed measure constitute a purer

[6] The standardised residuals in each analysis displayed only a slight tendency to increase in line with the values of the dependent variable.

measure of perceived control. Moreover, the findings suggest that reinforcement frequency ceases to be a determinant of the degree of illusorily perceived control once the effects of existing task-related beliefs are controlled for and the degree of perceived control is measured as a multi-faceted construct associated with causal explanations for success.

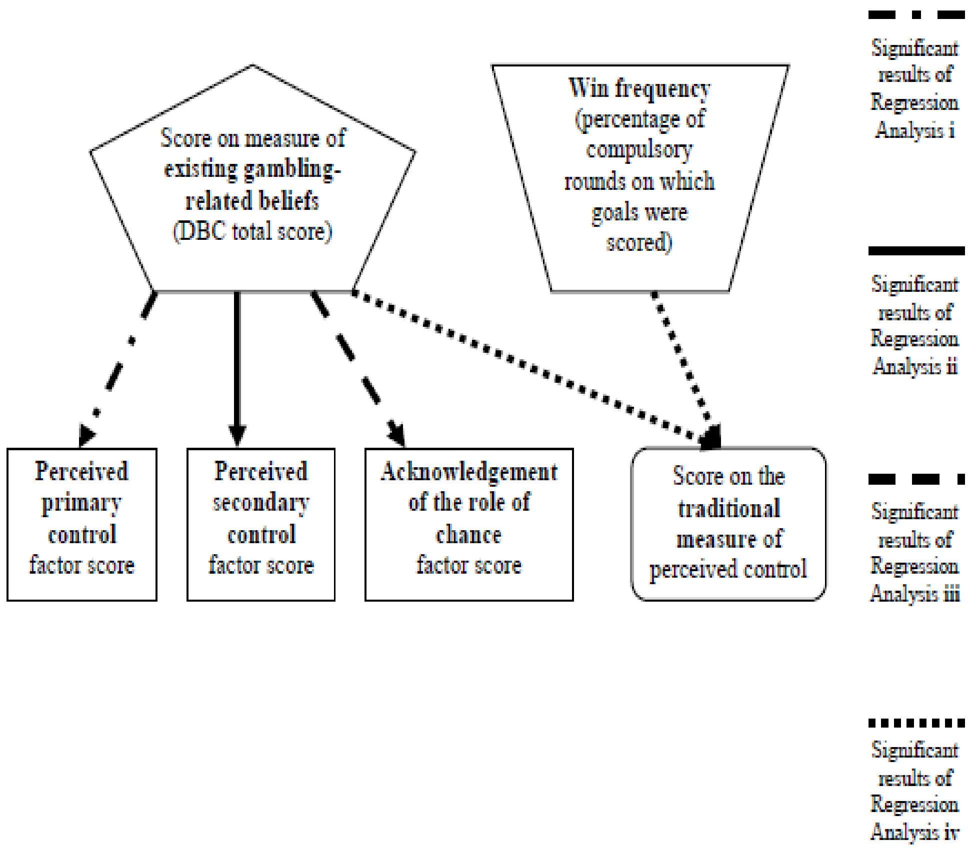
Discussion

Motivated by a concern for the finer methodological points of investigating the determinants of the illusion of control, we used a novel experimental task, instructional set and pre-experimental belief assessment procedure to demonstrate two important advantages of a newly-developed measure of illusorily perceived control. Firstly, ratings of agreement with the various causal explanation statements comprising the measure were found to reflect a distinction between primary and secondary control – a distinction not recognised by the traditionally employed single-item measure. Secondly, responses to the newly-developed measure were, in contrast to responses to the traditional measure, found to be completely independent of the experienced reinforcement frequency.

The present findings were additionally informative with respect to the definition of the illusion of control construct and the body of research on the person-based and situational determinants of the illusion.

Definition of the illusion of control

Our factor analysis produced quantitative evidence for what has up to this point been the largely qualitative observation that illusions of control involve perceptions of secondary as well as primary control. The analysis also uncovered a third facet of the illusion: ‘acknowledgement of the role of chance’. Subsequent regression analyses produced evidence of a differentiation, in terms of dependence on win frequency, between the perceived degree of “control” and the three facets of causal explanation for experienced successes.



Regression Analysis i: Perceived primary control

Step	Predictors	B	*SE* B	β	t	*p*	Adj R^2
1	Constant	-1.73	0.32				.24
	DBC total score	-0.03	0.01	-.50	-5.55	<.001	
2	Constant	1.80	0.33				.24
	DBC total score	-0.03	0.01	-.49	-5.35	<.001	
	Win frequency	-0.01	0.01	-.08	-.89	.38	

Regression Analysis ii: Perceived secondary control

Step	Predictors	B	*SE* B	β	t	*p*	Adj R^2
1	Constant	-1.73	0.33				.23
	DBC total score	0.03	0.01	.49	5.44	<.001	
2	Constant	-1.88	0.34				.25
	DBC total score	0.03	0.01	.47	5.18	<.001	
	Win frequency	0.01	0.01	.16	1.80	.08	

Regression Analysis iii: Acknowledgement of the role of chance

Step	Predictors	B	*SE* B	β	t	*p*	Adj R^2
1	Constant	1.27	0.27				.19
	DBC total score	-0.02	0.004	-.45	-4.83	<.001	
2	Constant	1.33	.28				.19
	DBC total score	-0.02	0.004	-.43	-1.18	.24	
	Win frequency	-0.004	0.004	-.09	-1.15	.25	

Regression Analysis iv: Score on traditional measure

Step	Predictors	B	*SE* B	β	t	*p*	Adj R^2
1	Constant	-1.23	0.55				.23
	DBC total score	0.05	0.01	.50	5.68	<.001	
2	Constant	-1.77	0.53				.34
	DBC total score	0.04	0.01	.43	5.17	<.001	
	Win frequency	0.03	0.01	.35	4.17	<.001	

Figure 3.3. Hierarchical regression analyses of the influence of gambling-related beliefs and win frequency on responses to the traditional measure of illusorily perceived control and the newly-developed measure (N = 96)

This collection of findings accords with Skinner, Chapman and Baltes' (1988) proposition that, in perceiving control, agents draw upon beliefs about relations between themselves and ends (the available reinforcement), means (potential causes) and ends, and themselves and means, with each of these three types of relational beliefs being held *independently* of the others. Within this framework, ratings of control on the traditional measure could, in light of their positive relationship with win frequency, be considered reflective of agent-ends-type beliefs. Meanwhile, responses to the newly-developed causal explanations measure constituted expressions of means-ends-type beliefs about the game. In fact, the three-faceted structure uncovered by our correlational analysis of responses on this measure corresponded to the structure obtained by Skinner, Chapman and Baltes (1988) in an analysis of children's agreement ratings for means-end-type statements about school performance. In that study, ratings pertaining to personal effort and attributes were found to form one cluster (analogous to our "primary control" facet) while ratings pertaining to powerful others and luck formed a second cluster (analogous to our "secondary control" facet). A third cluster was defined by ratings on statements about unknown causes, of which 'chance' is an instance, at least from an intuitive point of view (Batanero, Henry & Parzysz, 2005), and most prominently among children (Biehl & Halpern-Felsher, 2001; Green, 1984).

While this correspondence between findings importantly demonstrates that illusions of control have the same etiology as perceived control in general, Skinner, Chapman and Baltes' framework does not account for the source of segmentation in control beliefs. The adaptive advantages of possessing three independent belief types as opposed to an integrated representation of agent-means-ends relations remain unspecified. Lewandowsky and Kirsner (2000) proposed that contradictions in expressed beliefs stem from variations in the context of knowledge acquisition and utilisation. Whether the contexts governing the acquisition of information about primary strategies, as opposed to 'higher forces', 'chance' and 'control', differ systematically is an open question.

Determinants of the illusion of control

Prior beliefs

The results of our regression analyses highlighted the prominence of pre-experimentally assessed gambling-related beliefs in shaping perceptions of control. One could argue that it is hardly surprising that beliefs about poker machine gambling were found to influence perceptions of a task introduced to participants as a "poker-machine-type game". However, in real gambling environments, all people – regardless of prior gambling experience – approach poker machines with precisely the knowledge that they are about to play something called a 'poker machine' and a set of beliefs about the nature of poker machine gambling.

At the same time, a legitimate question to pose is whether self-reported gambling-related beliefs precede and determine illusions of control over game-specific stimuli, or whether these beliefs simply covary with game-specific perceptions of control. The covariation could be underpinned by the optimal organisation of control beliefs suggested by Skinner, Chapman and Baltes (1988) or the variations in acquisition and usage postulated by Lewandowsky and Kirsner (2000). In the present study, the DBC Inventory was selected as a measure of gambling-related beliefs due to its brevity, focus on poker-machine-gambling, and relevance to a population without extensive gambling experience (namely, the university students in our sample). A disadvantage of the measure is that its items related principally to *a priori* beliefs about illusory control and superstition. Thus, future research should concern itself with tracking the determining effects of a broader set of gambling-related beliefs – most notably, those relating to what Walker (1992b) considered the second broad dimension of erroneous gambling-related cognitions: optimism or hopefulness about winning independently of control attempts. In general, the structure of gambling-related beliefs among members of the general community and frequent gamblers requires examination.

Reinforcement frequency

Crucially, reinforcement frequency, a situational feature that has long been considered a fundamental determinant of the degree of illusorily perceived control, was found to exert no influence on perceptions of control, as gauged by the newly-developed, more subtly worded measure. While this result requires replication, perhaps with a different range of reinforcement frequencies, ensuing studies could also explore the illusion-of-control-elicitation effects of other, more gambling-specific outcome sequence features, such as the frequency of big wins (Aasved, 2002), the general ordering of wins and losses (e.g., whether wins are concentrated at the beginning or end of the sequence; Burger, 1986; Coventry & Norman, 1998; Langer & Roth, 1975), and the degree of 'need for control' in the face of losses exceeding a certain threshold (Walker, 1992b).

Whatever set of potential determinants is selected for further investigation, future research could fruitfully make use of the experimental task, procedure and multi-faceted outcome measure described and piloted in the present study.

Appendices for Chapter 3

Appendix 3A

Table 3A.1. Bet and win-amount values across success-frequency conditions

		Bet option													
		Goal on next shot (1)		Goal on next shot (2)		Goal on next shot (3)		Goal on next shot (4)		One goal in next two shots		Two goals in next three shots		Three goals in the next three shots	
Cond.	Starting credit count	Bet amt (A[ψ])	Win amt (T)	Bet amt (B)	Win amt (U)	Bet amt (C)	Win amt (V)	Bet amt (D)	Win amt (W)	Bet amt (E)	Win amt (X)	Bet amt (F)	Win amt (Y)	Bet amt (G)	Win amt (Z)
1/16	700*	1	14	2	30	5	78	10	140	4	32	30	164	4	992
1/8	700*	1	7	2	15	5	39	10	70	4	17	30	87	4	248
1/4	7000**	10	35	20	75	50	195	100	350	40	89	300	498	60	3760
1/3	7000**	10	27	20	57	50	147	100	263	40	498	300	409	60	1587
1/2	7000**	10	18	20	38	50	98	100	175	40	3760	300	1587	60	470

* Credit value: 1 credit = 1 cent
** Credit value: 10 credits = 1 cent
ψ The letters A to Z correspond to the annotation system adopted in describing the bet option selection screen – Screen 3 – in Figure 3.1

Appendix 3B

Given the criteria used for excluding weak items from the factor analysis, the 'Chance' item should have been excluded instead of being left to form a third factor. Since factor scores were subsequently used as dependent measures, all results presented in the paper might have been affected by this oversight. This appendix presents the main results of the paper with the 'Chance' item excluded. In the factor analysis of the newly-developed measure, distinct measures of the illusion of primary and secondary control still emerged and success-frequency still did not have an effect on either of them.

Factor analysis

With the 'Chance' item excluded from analysis, the scree plot, mineigen (eigenvalue > 1) and parallel-analysis criteria for how many factors to extract (e.g., Hayton, Allen & Scarpello, 2004) all suggested a two-factor solution. Table 3B.1 shows the factor loadings for a two-factor solution following a direct oblimin rotation. The factors correspond to the illusion of primary control and the illusion of secondary control in that they are defined by the same items as in the original factor analysis result. Communalities and Cronbach's alpha values, not reported here for the sake of brevity, were also similar to those in the original analysis.

Reinforcement frequency and perceived control

Consistently with the original results, factor scores on the two constructs derived in the above factor analysis were significantly predicted by DBC scores, but not success-frequency. That is, once DBC scores were accounted for in the first step of a hierarchical regression, the introduction of success-frequency at the second step did not result in a significant *F*-value change in perceived primary control (p = .32) or perceived secondary control (p = .11).

Table 3B.1. Factor loadings produced by a PAF analysis with oblimin rotation for 10 retained statements of the newly-developed measure (N = 97)

	Factor loadings	
Statement referring to:	F1 Secondary control	F2 Primary control
Lucky play pattern	.91	
Lucky person	.67	
Player profiles	.64	
Knowledge of luck	.63	
Lucky moments	.57	
Goalkeeper	.56	
Practice		.88
Skill		.71
Strategy		.61
Computer games		.55

Note: Factor loadings <.4 are suppressed

CHAPTER 4: Paper 2

Success-slope effects on the illusion of control and on remembered success-frequency

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Submitted for publication

Abstract: The illusion of control refers to the inference of action-outcome contingency in situations where outcomes are in fact random. The strength of this illusion has been found to be affected by the pattern of successes and failures experienced over time in what can be termed a 'success-slope' effect. Previous studies have generated inconsistent findings regarding the nature of this effect. In this paper we present an experiment (*N* = 334) that overcomes several methodological limitations within this literature, employing a wider range of dependent measures (measures of two different types of illusory control, primary and secondary, as well as measures of remembered success-frequency). Results indicate that different dependent measures lead to different effects. On measures of (primary) control over the task, scores were highest when the rate of success increased over time. Meanwhile, estimates of success-frequency in the task did not vary across conditions and showed trends consistent with the broader literature on human memory.

Introduction

Participants asked to determine the degree of contingency between their press of a button and the onset of a light increase their ratings with light onset frequency even when the light is objectively uncontrollable (Alloy & Abramson, 1979; Jenkins & Ward, 1965). People place greater value on lottery tickets they have personally chosen than on tickets that have been handed out (Langer, 1975; Wohl & Enzle, 2002). Slot-machine players choose machines that have not paid out in some time and make use of rituals and lucky charms (Henslin, 1967; Livingstone, Wooley & Borrell, 2006; Schippers & Van Lange, 2006; Wood & Clapham, 2005). All of these phenomena are considered instances of the 'illusion of control', the overestimation of contingency between personal actions (strategies) and task outcomes in games of chance. The illusion is thought to be caused by situational factors (e.g., the availability of a choice between action alternatives) in interaction with held beliefs about these factors. In this sense, the illusion is an inference based on situational information and prior beliefs (Crocker, 1981; Harris & Osman, 2012). The illusion expresses itself in repeated behaviours (e.g., strategic errors, rituals) as well as explicit ratings of control over real-world and laboratory gambling tasks.

In light of the many potential real-world consequences of illusory control inferences, a large number of laboratory studies have addressed their situational determinants (for a review, see Thompson, Armstrong & Thomas, 1998). The studies typically involve a laboratory task with objectively random outcomes, and the task tends to be either familiar (e.g, roulette) or novel (e.g., a button-and-light device). A single situational determinant is manipulated and post-session estimates of control or success-frequency serve as the dependent measure. The most frequently investigated situational determinants have been success-frequency (e.g., Alloy & Abramson, 1979; Thompson et al., 2007) and opportunity for choice and physical involvement (e.g., Ayeroff & Abelson, 1976; Ladouceur & Sevigny, 2005; Langer, 1975). Other identified determinants include need for the outcome (e.g., Biner, Huffman, Curran & Long, 1998; Gino, Sharek & Moore, 2011) and the opportunity for practice (e.g., Benassi, Sweeney & Drevno, 1979).

This paper aims to resolve conflicting findings regarding another identified situational influence, namely the 'success-slope' (also known as 'the sequence of outcomes'; Langer & Roth, 1975). This term refers to how successes and failures are positioned relative to each other in a randomly-generated outcome sequence. A sequence with a descending success-slope begins with a string of successes and concludes with a string of failures. In contrast, a sequence with an ascending slope is characterised by a preponderance of successes at the end.

It is not difficult to propose theoretical reasons for why these three conditions might lead to different judgments. For instance, it has been argued that in a ‘descending’ condition, people are motivated to see themselves as effective agents in the task, and so focus heavily on early successes (Langer & Roth, 1975; Thompson, Armstrong & Thomas, 1998). On the other hand, it has been suggested that a run of late successes in the ‘ascending’ condition acts to strengthen control inferences by creating the impression of learning (Matute, 1995). The difficulty, however, lies in the fact that the empirical findings on this effect are mixed.

To date, five experiments have examined ratings of control and success-frequency following the experience of 30 or so outcomes conforming to the ‘descending’, ‘ascending’, or ‘flat’ structures. Their findings regarding the direction of the effect were not consistent. Four studies concluded that inferred control is greatest in the ‘descending’ condition (Burger, 1986; Coventry & Norman, 1998; Ladouceur & Mayrand, 1984; Langer & Roth, 1975), but one study found that inferred control was larger in the ‘ascending’ condition (Matute, 1995). Indeed, one study found that *both* the ‘descending’ and ‘ascending’ conditions showed a stronger effect than the ‘flat’ condition (Burger, 1986).

When one looks at the literature a little more closely, a number of difficulties present themselves. The first issue is the potential conflation of the illusion of control with memory effects; that is, the conflation of what is *inferred* with what is *remembered*. This issue arises when participants are asked to judge the number of successes that they have had, and these judgments are used as a measure of inferred control. To illustrate the problem, we note that the conclusions of Langer and Roth (1975) are based on observing that participants in the ‘descending’ condition provided significantly higher estimates in response to the following three questions: “How many correct predictions did you have on the 30 trials?”, “How many correct predictions do you think you would have had on the next 100 trials?” and “How good do you think you are at predicting outcomes like these?”. None of these questions directly ask about the degree of *control* people perceive themselves to have. Responses to these questions could be influenced by factors other than one’s beliefs about ability to control the outcome.

A second problem pertains to the issue of what it actually means to measure “inferred control”. Even when inferred control is measured separately from estimated success-frequency, the literature on the success-slope effect tends to treat inferred control as a unitary construct that can be measured using a single question. As an example, Burger (1986) relied on a single question asking people to rate the "extent to which you believe that your correct answers were the result of your ability to correctly anticipate events". There is some evidence to suggest that the illusion of control is a more complicated phenomenon. In a review of the illusion-of-control literature, Rothbaum, Weisz and Snyder (1982) distinguished between two different kinds of perceived control, 'primary' and 'secondary'. Primary control refers to the belief that outcomes can be influenced through personal skill. In contrast, secondary control refers to the belief that external forces (e.g., luck, God) control the outcome, but one can be aligned with these forces. A statement like "I knew how to make my luck work for me" is a good example of a belief in secondary control, insofar as it implies that luck controls the outcome but is favouring the speaker. In the broader cognitive science literature, a similar distinction has been drawn between beliefs about physical entities and superstitious (or religious) beliefs about supernatural entities (e.g., Atran and Norenzayan, 2004; Wellman & Gelman, 1992). The illusion that physical (i.e., skilled) actions are effective in a game of chance would correspond to the illusion of primary control, while a belief in the effectiveness of superstitious or religious rituals would correspond to the illusion of secondary control.

In view of the evidence that primary and secondary control are distinct constructs, it seems sensible to measure inferred primary and secondary control separately. To that end, we will follow a previous study (Ejova, Delfabbro & Navarro, 2010) in adopting a factor-analytic approach. That is, we will treat primary and secondary control as *latent* variables, estimated by analysing a questionnaire that asks people to rate their agreement with a number of statements, such as "I got better with practice", "My skill in playing the game [helped me win]", "I've always been a lucky kind of person", and "A certain lucky way of playing just seemed to work for me". Factor analysis of the responses is expected to reveal clusters of 'primary' and 'secondary' statements (Ejova et al., 2010). The factor scores recovered for individual participants can then be used as the measures of inferred control.

A third issue that we consider is the choice of control conditions. As noted earlier, the success-slope literature uses the 'flat' condition as a control for the two conditions that have success-slopes, namely the 'descending' condition and the ‘ascending’ condition. Not all studies have used all three conditions. In our study, we include all three, and include an additional ‘U-shaped’ condition, in which there are clusters of wins at the beginning and at the end. If early wins and late wins have distinct effects on perceived control, this condition might be expected to lead to the highest levels of perceived control. Even so, the inclusion of this new condition is more exploratory than hypothesis driven.

In sum, our study aims to test the direction of the success-slope effect in a way that addresses and demonstrates two methodological issues: the difference between inferred control and remembered win frequency, and the two-faceted nature of the illusion of control.

Method

Participants

There were 334 participants (171 males), ranging in age from 18 to 80 (M = 25.0, SD = 11.0) and incorporating members of the general community alongside undergraduate psychology students at the University of Adelaide. Recruitment was conducted through a newspaper advertisement, advertisements placed around campus, and through a research participation website accessible to undergraduate psychology students. As is standard in studies of gambling, participation was conditional on being over the age of 18, having gambled at a licensed venue at least once previously, and not being in the process of receiving treatment for gambling-related problems. Psychology students received course credit for participating.

Materials, measures and procedure

The experiment was a self-contained 30-minute computerised exercise divided into four stages. These were: (1) a pre-experimental questionnaire, (2) 48 trials of the experimental task, a “soccer-themed gambling task”, (3) the post-experimental questionnaire, and then (4) additional trials of the experimental task, if the participant so desired[7]. The four different success-slope conditions (the independent variable) corresponded to differences in the sequence of outcomes experienced during the

[7] The total number of rounds played was recorded as part of a broader investigation into behavioural and questionnaire-based measures of the illusion of control.

experimental task (stage 2), but in all other respects the conditions were the same. The dependent measures and covariates all derive from the two questionnaires. The description below gives a broad overview of the study: additional details can be found in the Appendices (4A and 4B).

The pre-experimental questionnaire

To maximise ecological validity, our experimental task resembled a real-world gambling task. To accommodate this, a pre-experimental questionnaire was used to measure participants' beliefs about gambling. The obtained scores were, in turn, used as covariates in analyses of the relationship between success-slope and inferred control and between success-slope and remembered success-frequency. Similarly, because the surface form of the task was based on soccer, the pre-experimental questionnaire also measured interest in soccer, which then served as a covariate in the major analyses.

The measures used were as follows. For beliefs about gambling, we used the Drake Beliefs About Chance Inventory (DBC; Wood & Clapham 2005), a 22-item questionnaire that is organised into two scales, one relating to superstitious beliefs (*DBC-Secondary*) and the other to more conventional erroneous beliefs about chance events (*DBC-Primary*; see Appendix 4A.1). To measure interest in soccer, we asked people to rate their interest on a five-point Likert scale (see Appendix 4A.1).

The experimental manipulation

The independent variable, success-slope, was manipulated across four between-subjects conditions. In the 'descending' condition (N = 85), early wins were followed by a string of losses. For the 'ascending' condition (N = 79), the opposite was the case, and in the 'flat' condition (N = 84), wins were approximately evenly distributed across the playing session. The 'U-shaped' condition (N = 86) featured a concentration of wins at the beginning and at the end. In all conditions, participants experienced a win on 8 of the 48 trials.

The soccer-themed gambling task

The experimental task was a soccer-themed computerised task modelled after a slot machine in several respects: the option to bet on the results of multiple trials corresponded to the option to vary the number of lines played on a slot machine; there were more near misses than far misses; sound effects corresponded to those heard on slot machines; and bet and win-amounts for each betting option were calibrated to result in a long-term loss of 10% of used money, the return rate on South Australian slot machines.

The task instructions, issued verbally and in writing at the start of the session, emphasised that the task operated on the same principles as real slot machines, and that any credits won during the game would be exchanged for cash at the end. Participants played the game for a compulsory 48 trials, with any additional rounds being voluntary. Participants began the task with 5000 credits, which, they were informed, was equivalent to $AUD5.

An overview of the experimental task is shown in Figure 4.1. Each trial of the task displayed an on-screen soccer player taking a free kick, and participants were required to bet on the player scoring a goal. Several betting options were available, including some options that involved betting on the results of multiple trials (e.g., that the player would score three times in a row; Screen 2 in the figure). Other choices were also required. First, at the start of the game, participants were required to choose from among four different real-world players, each of whom had an entertaining biography provided (Screen 1). A change of player profile could be made after any round. Also, on each trial, participants chose which of the four corners of the goal the player kicked towards, a 'random' option also being available (Screen 3). None of these choices influenced the outcome sequence, which was fixed for the first 48 trials in all four experimental conditions.

The outcome itself was displayed as an animation showing a goal being scored or a miss (Screen 4). The ball was shown to move in the direction that the participant selected, with a random number generator determining, on a trial-by-trial basis, whether or not the outcome was shown to be 'close'. For example, for misses, the randomly-generated number determined whether the shot was shown to be a near-miss caught by the goalkeeper, or a far miss well clear of the goal posts.

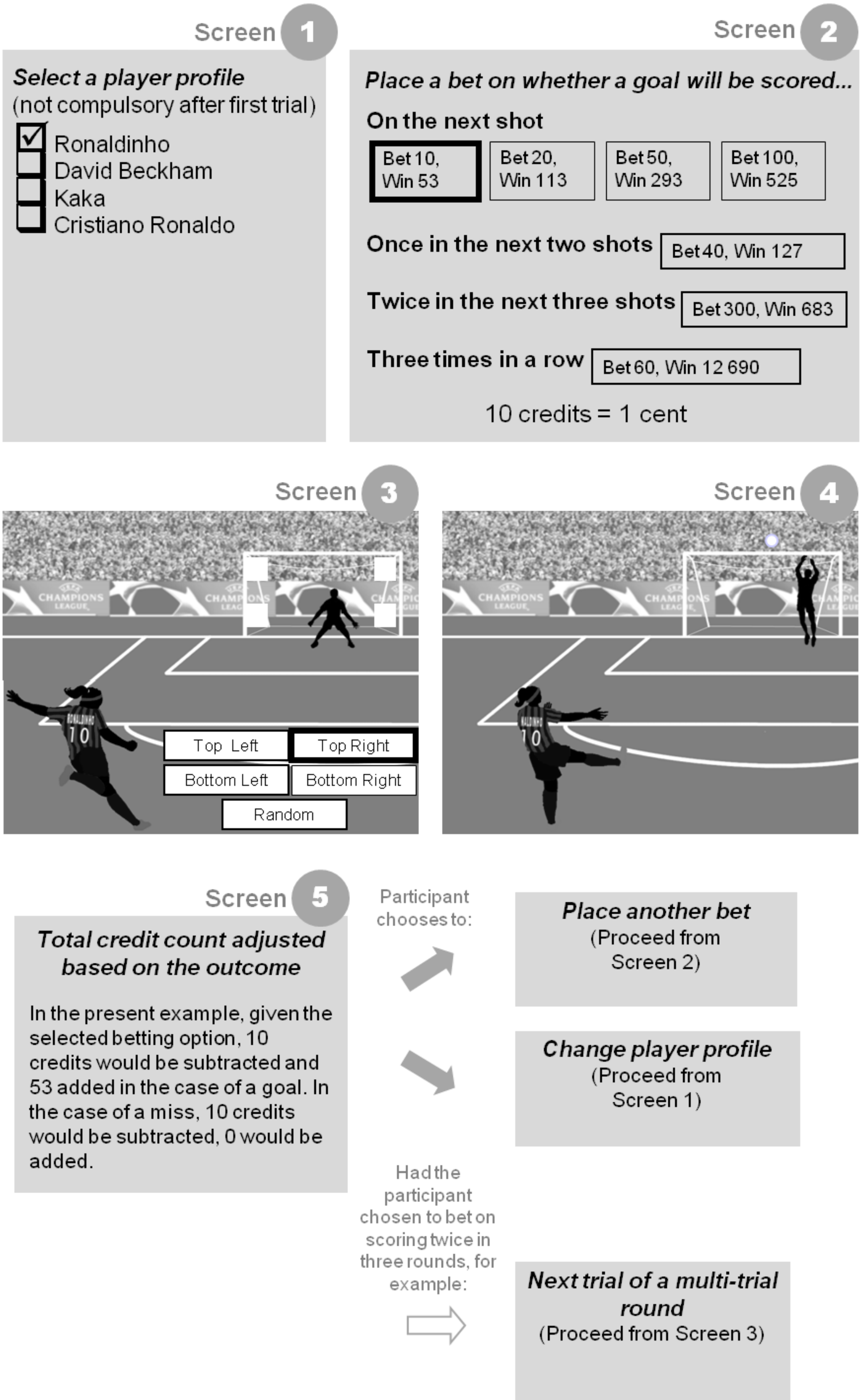

Figure 4.1. Experimental task interface

The animation was followed by confirmation of the outcome, sounds of applause in the event of a goal, and adjustment of the credit count (Screen 5). Credits were subtracted in each round, and added whenever a goal or multiple goals were scored in line with the chosen betting option.

The post-experimental questionnaire

After participants completed the experimental task, we administered a questionnaire designed to elicit their conclusions about the task. It is from this questionnaire that our dependent measures were constructed.

To measure perceived control, we presented participants with the 15 items outlined in Table 4.1, and used factor analysis to reduce these 15 manifest variables to two latent variables, which (as outlined in the Results) loosely correspond to illusory primary and secondary control. These two variables formed our dependent measures for the two kinds of illusory control.

The other dependent measures related to success-frequency. The *retrospective success-frequency* item asked people to state the percentage of shots that resulted in goals, whereas the *prospective success-frequency* item framed the question in terms of the percentage of successes the participant would expect to see if the task were continued (see Appendix 4A.3). For the retrospective item, the question was framed in terms of number of wins for half the participants, and in terms of the number of losses for the other half (for data analysis, we converted all responses to the "wins" format by subtracting responses in the loss frame from 100).

The final component of the post-experimental questionnaire was a manipulation check item, intended simply to verify that participants noticed the success-slope to which they were exposed. Responses to this question confirmed that the manipulation was successful, especially in the 'descending' condition, where 78% of participants indicated that "noticeably more wins occurred at the beginning" (see Appendix 4A.4 for more details).

Table 4.1. The main measure of inferred control in the post-experimental questionnaire (Ejova, Delfabbro & Navarro, 2010)

When thinking about your wins/goals, to what extent would you use each of the following statements to describe how they came about? Rate each of the statements using a number from 0 to 10. As a guide, give a rating of 0 if you think that the phenomenon described by the statement was not one of the reasons, a rating of 5 if you think the phenomenon was a moderately important reason, and a rating of 10 if you think that the phenomenon was one of the most important reasons.

1.[~]	I got better with practice.
2.	I learned how to predict the movements of the goalkeeper.
3.	My skill in playing the game
4.	Experience at playing computer games
5.	The kick directions I chose [∝]
6.	My knowledge of soccer
7.	I developed a logical strategy for playing the game.
8.	The player(s) I chose
9.	The bet options I chose [∝]
10.	I deserved to win.
11.	I've always been a lucky kind of person.
12.	A certain lucky way of playing just seemed to work for me.
13.	I took advantage of moments when my luck was good.
14.	I knew how to make luck go my way.
15.	It was all chance.

[~] Statement order was randomised for each participant

[∝] Statements added to the set used by Ejova, Navarro and Delfabbro (2010)

Additional methodological details

Three additional methodological details are worth noting. Firstly, we wished to check that participants understood the instruction that the task was a gambling game rather than a solvable video game. To this end, the post-experimental questionnaire contained a yes/no question about whether a strategy was used. Those answering affirmatively were asked to describe the strategy. Participants, on the whole, could be concluded to have understood the instruction if some of the described strategies reflected reasoning typically observed in the face of random outcomes – gambler's-fallacy-type reasoning (e.g., increasing bet amounts after a number of losses in expectation of an imminent win; Tversky & Kahneman, 1974). As a listing of the strategies in Appendix 4D[8] shows, a substantial number of described strategies appeared to be informed by the gambler's fallacy.

[8] Presented as an online supplement in the submitted version of the paper.

Secondly, to conceal the purpose of the experiment from participants, the pre- and post-experimental questionnaires contained distractor items in addition to the theoretically interesting ones mentioned earlier. A mood questionnaire (Lorr & Wunderlich, 1988) was included in both the pre- and post-experimental questionnaires, and the post-experimental questionnaire required Likert or 10-point-scale-based ratings of enjoyment of the game, strength of experienced emotional responses, and the extent to which the player profile feature and sound effects added to or reduced enjoyment. For the sake of brevity, we do not describe or analyse these items.

Finally, debriefing focused on explaining that none of the task's choice features (player profiles, kick directions, betting timing) influenced outcomes (see Appendix 4E[9]). We also took care to check whether our participants were at risk of experiencing gambling problems. To that end, the pre-experimental questionnaire also included the Problem Gambling Severity Index (Ferris & Wynne, 2001). If a participant's responses indicated that a risk of problem gambling existed, this was surreptitiously communicated to the experimenter via the colour of the on-screen message displaying the cash-out amount to be paid to the participant. Debriefing for these participants additionally involved providing them with an information sheet with help-service contact numbers.

Results

Estimating inferred control

As noted in the previous section, we used a 15-item question (Table 4.1) to assess participants' inferences about control, and used factor analysis to reduce responses to two theoretically interpretable latent variables. Ejova, Navarro and Delfabbro's (2010) procedure for doing this was followed, with the items first being screened for sufficient variability and intercorrelation. Given that this analysis was complex and is not the central topic of investigation, details are relegated to Appendix 4C, and only a brief overview is provided here. Two items (9 and 15) were removed from the analysis because their correlations did not appear robust. The remaining 13 items

[9] Not included in the submitted version of the paper.

loaded naturally onto two factors. The first factor consists of items 1-8, and can be interpreted as primary control, insofar as it consists of statements that refer to strategies and game features. Items 10-14 form a factor that resembles secondary control, inasmuch as it is defined by statements referring to luck and its sensitivity to deservingness. The factors were highly correlated[10].

In addition to estimating the factor loadings of each item on the two latent variables, we calculated the factor scores for each participant, corresponding to the score that each participant is estimated to have on those variables. Specifically, because our two latent variables were correlated, we computed regression factor scores, an aggregate score suitable for describing an individual's position on correlated factors (DiStefano, Zhu & Mîndrilă, 2009).

For the purposes of subsequent analyses, note that the regression factor scores standardised to a mean of zero, so negative factor scores indicated lower ratings on the statements associated with the factor, while positive scores indicated greater endorsement (greater inferred control). The distributions of both primary and secondary control factor scores were highly positively skewed (skew = .73 and .67, respectively), and had standard deviations of .96 and .92, respectively. It is these factor score variables that we use as our measures of perceived control in subsequent analyses.

Inferred control across success-slopes

To test the direction of the success-slope effect, scores on the two perceived control measures produced by the factor analysis were examined across success-slope conditions. This involved analyses of covariance (ANCOVAs) with success-slope condition as the predictor and two covariates: soccer interest and slot-machine beliefs as measured by the DBC. The 'Primary' scale of the DBC, relating to non-superstitious beliefs about chance, was the covariate in the analysis of the perceived primary control measure. Correspondingly, the DBC's 'Secondary' scale, concerned

[10] This is to be expected, given that numerous researchers have remarked that, in gambling contexts, beliefs in personal skill at predicting chance outcomes and some beliefs about luck (namely, the common belief that good luck comes in 'cycles') might have the gambler's fallacy as a common source (Keren & Wagenaar, 1985; Livingstone, Wooley & Borrell, 2006).

with superstitious and supernatural beliefs, was the covariate in the analysis of perceived secondary control[11].

The degree of perceived primary control was found to vary as a function of success-slope ($F(3,328) = 1.95$, $p = .03$ ${}_p\eta^2 = .03$) once the substantial effect of slot-machine beliefs (DBC-Primary) was controlled for ($F(1,328) = 120.21$, $p < .001$, ${}_p\eta^2 = .27$)[12]. Figure 4.2 shows the estimated means for primary control when DBC-Primary was set to a constant (mean) value[13]. As the distribution of means suggests, and as was confirmed by post-hoc tests with Bonferroni adjustment of the familywise α-level to .05, the estimated primary control mean was greater in the 'ascending' condition relative to the 'descending' condition ($p = .04$).

Perceived secondary control was not affected by success-slope, but was predicted by slot-machine beliefs ($F(1,328) = 114.63$, $p < .001$, ${}_p\eta^2 = .26$). Thus, the crucial result pertained to perceived primary control, with the 'ascending' condition producing stronger inferences than the 'descending' condition.

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[11] All three covariates were checked for homogeneity of variance across experimental conditions using univariate analysis of variance (all $F(3,330) < 1$). DBC-Total, used as a covariate in some later analyses, was also homogenous across conditions ($F(3,330) < 1$).

[12] Since the distribution of perceived primary control scores was highly skewed, a generalised linear model suitable for ordinal data was also fitted. The independent variable and covariates were the same as for the ANCOVA, but the model assumed a multinomial distribution and used a cumulative logit link function. The effect of success-slope was found to be marginally significant (*Wald* $\chi^2(3) = 7.35$, $p = .06$).

[13] The marginal means for perceived primary control across experimental conditions were as follows. Descending: $M = -.2$, $SD = .8$; U-shaped: $M = .04$, $SD = 1.0$; Ascending: $M = .2$, $SD = 1.1$; Flat: $M = .02$, $SD = 1.0$.

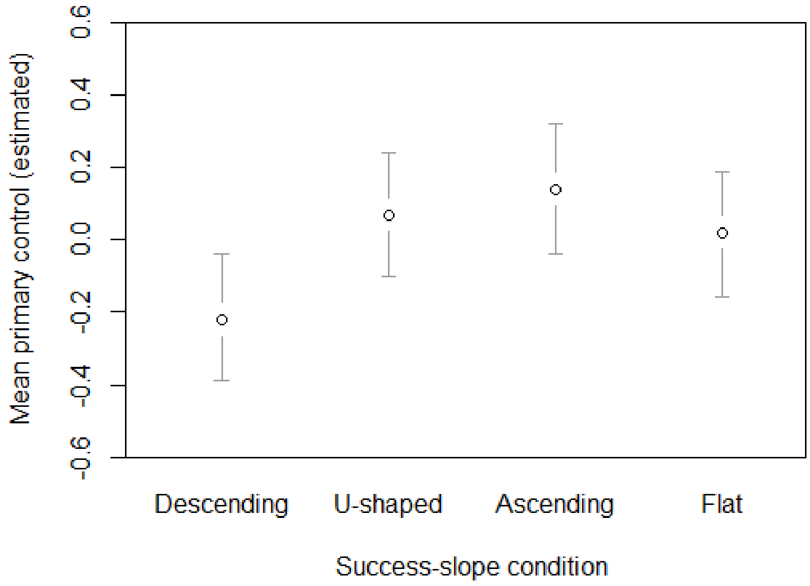

Figure 4.2. Estimated means (and 95% CIs) of inferred primary control across success-slope conditions when covariates were evaluated at their mean values

Inferred control vs. remembered success-frequency

To formally test the widespread methodological assumption that estimated success-frequency is a suitable proxy for control, success-frequency estimates (retrospective and prospective) were examined for their pattern across success-slope conditions. This pattern could then be compared to that observed for inferred primary control.

Since success-frequency estimates on both measures were not normally distributed (as is typical with count data), the analysis of responses to each measure across success-slope conditions involved fitting a generalised linear model with an assumed negative binomial distribution and log link function. Gambling-related beliefs (DBC-Total) and soccer interest served as covariates in both analyses, and the analysis of retrospective frequency estimates had question framing (frequency of ‘goals’ vs frequency of ‘misses’) as an additional predictor. The analyses were conducted using *IBM SPSS Statistics 19*.

Estimates of retrospective success-frequency were found to be influenced by question framing (*Wald* $\chi^2(1) = 21.32$, $p < .001$) but not success-slope (*Wald* $\chi^2(3) = 5.23$, $p = .16$) or the interaction between framing and success-slope (*Wald* $\chi^2(3) =$

6.82, p = .08). Table 4.2 shows the estimates across success-slope conditions, broken down according to question frame. It can be seen that, across all conditions, estimates were higher when the question referred to 'misses'. As far as the effect of success-slope itself is concerned, the table shows that there was a trend towards higher estimates in the 'descending' condition relative to the 'ascending' condition. This trend is in the opposite direction to that observed for inferred control ratings. To highlight this contrast, Figure 4.3 complements Figure 4.2 in showing mean retrospective success-frequency estimates across conditions, adjusted for covariates.

Table 4.2. Mean remembered success-frequency estimates across success-slope conditions

	'Descending'		'U-shaped'		'Ascending'		'Flat'	
Estimate type	*M* (*SD*)	CI_{95}	*M* (*SD*)	CI_{95}	*M* (*SD*)	CI_{95}	*M* (*SD*)	CI_{95}
Retrospective: goals	22.2 (14.7)	17.7-26.8 [>]	14.6 (8.8)	11.7-17.4	17.8 (12.7)	13.6-22.0	15.6 (12.8)	11.6-19.7
Retrospective: misses	30.9 (22.9)	23.7-38.0[>]	33.2 (24.7)	26.0-40.5[>]	19.6 (13.3)	15.4-23.8	33.4 (28.7)	24.9-41.8[>]
Prospective	22.9 (15.7)	19.5 – 26.2[>]	20. (14.0)	14.9-24.5	19.4 (14.3)	16.2-22.6	21.4 (13.)	18.4-24.4[>]

[>] CI contains only values above the objective baseline success-frequency (16.7%), suggesting general overestimation
[<] CI contains only values below the objective baseline success-frequency (16.7%), suggesting general underestimation

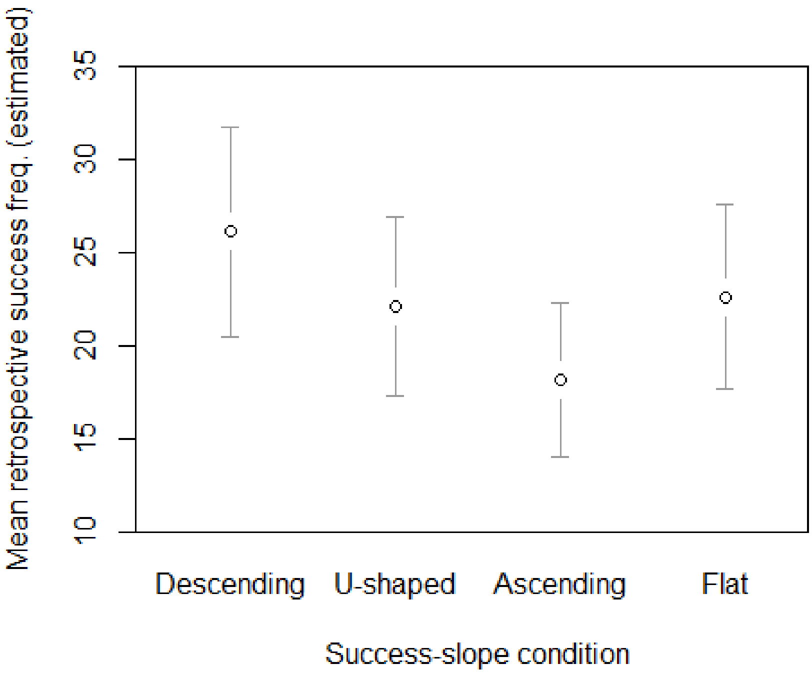

Figure 4.3. Estimated means (and 95% CIs) of retrospective success-frequency estimates across success-slope conditions when covariates were evaluated at their mean values

Estimates of prospective success-frequency also did not differ significantly across experimental conditions (*Wald* $\chi^2(3) = 1.31$, $p = .72$), but showed the same general trend of higher estimates in the 'descending' condition. The means of the prospective estimates across conditions are shown in Table 4.2.

Success-frequency estimates showed additional notable regularities across conditions, as can be seen in Table 4.2. Namely, answers to the retrospective question in the 'miss' framing were largely overestimations of the objective success-frequency (1/6 = 16.7%). A further regularity was a general tendency towards overestimation in the 'descending' and 'flat' conditions.

Discussion

The success-slope effect

The main goal of this study was to determine which success-slopes produce stronger post-experimental inferences of illusory control. The results suggested that perceived primary control is largest in the ‘ascending’ condition and lowest in the ‘descending’ condition, with the ‘flat’ and ‘U-shaped’ conditions lying in the middle.

The fact that the ‘ascending’ condition produced the strongest inferences of control is broadly consistent with Matute’s (1995) proposal that experiencing an increasing rate of successes can create the false impression of learning the correct strategy. The findings can alternatively be interpreted as evidence that experiencing a decreasing win rate in the ‘descending’ condition leads to an accurate perception that no learning is occurring. Specifically, the ‘descending’ condition might provide participants with a strong signal that whatever strategy they are attempting to employ does not work. After all, the participant is presumably trying to produce the successes, but in the ‘descending’ condition the rate of such successes declines over time, making it very clear that these attempts have been unsuccessful.

Primary and secondary control

A second goal of the study was to employ more refined measures of the extent to which people perceived themselves to be in control of the outcome. In this respect, the outcomes are a little more mixed. On the positive side, the factor analysis did suggest that there are two distinct (but correlated) kinds of beliefs about control involved, consistent with Rothbaum et al. (1982) and Ejova et al. (2010). Moreover, it is reassuring to see that our measure of primary control within a complicated and realistic task produced a success-slope effect consistent with the results of a previous study that used a simpler design (Matute, 1995). These results suggest that the success-slope effect is not an artefact of a particular way in which questions about perceived control are worded, nor is it restricted to simplistic experimental designs.

On the negative side, part of our motivation for using richer measures of perceived control in the context of a rich and complicated task was to see if we could detect any interesting effects for secondary control. As noted in the Introduction, in real world gambling situations, people do make claims about secondary control. People often refer to 'luck' as an entity that can be on the gambler's side, for instance (e.g., Keren & Wagenaar 1985). This is partly reflected in our results, to the extent that the degree of secondary control that participants reported in our task did correlate with their score on the relevant scale of the Drake Beliefs about Chance questionnaire. However, we did not uncover any evidence for a success-slope effect with respect to secondary control.

Memory versus inferred control

One of our major concerns outlined in the Introduction was the possibility that asking people what they remember about outcome frequency is not a good substitute for asking them about the amount of control they perceived over that outcome. This concern was borne out, in that, unlike ratings of inferred control, estimates of remembered success-frequency were found not to be affected by success-slope. Moreover, the success-frequency estimates displayed trends consistent with those observed in the memory literature. For instance, studies of memory point to a 'spacing effect' – consistently better memory for stimuli more distributed across time (e.g., Glenberg, Bradley, Kraus & Renzaglia, 1983; Varey, Mellers & Birnbaum, 1990). The fact that we observed higher estimates in response to the 'miss' framing of the retrospective success-frequency question ("What percentage of the shots you kicked over the course of the game resulted in misses?") is consistent with this effect. Specifically, misses might have been remembered more poorly than goals because they were less widely spaced, with reverse-scoring of responses, therefore, producing overestimations.

Similarly, what has been termed an 'over-under effect' might have been operating in all conditions, manifesting itself in overestimation rather than accurate recall in the 'descending' and 'flat' conditions, and in accuracy rather than underestimation in the other two conditions. The effect refers to the tendency to overestimate low event frequencies and underestimate high ones (e.g., Begg, 1974; Erlick, 1964; Fiedler & Arbruster, 1994; Lichtenstein et al., 1978). Background beliefs about the task determine what constitutes 'low' and 'high' frequencies (Lichtenstein et al., 1978), so, given participants' beliefs about gambling and soccer, it is possible that the success-frequency of 1/6 was low in the context of the soccer task. The resultant upwards-adjustment of estimates in all conditions could have produced the observed pattern in the following ways. In the ‘flat’ condition, the ‘spacing effect’ could have produced accurate estimates, which were adjusted upwards to result in the observed overestimation. In the ‘descending’ condition, the well-known ‘primacy effect’, involving better memory for items and events at the beginning of a sequence (e.g., Murdock, 1962), could have resulted in accurate estimates, which were then adjusted upwards to produce the observed overestimation. In the ‘U-shaped’ condition, the ‘primacy effect’ would have been weaker because there were fewer target items (successes) to remember at the beginning of the sequence. Likewise, in the ‘ascending’ condition, there were no target items at the beginning of the sequence, so a ‘primacy effect’ could not occur. Thus, in these conditions, memory for successes might have been poorer but estimates might have been adjusted upwards as part of the ‘over-under effect’, resulting in the observed accuracy.

A ‘recency effect’, involving better memory for the last items in a sequence, has also been widely documented and might have been expected to manifest itself in higher estimates in the ‘U-shaped’ and ‘ascending’ conditions. However, the ‘recency effect’ is easily disrupted by interference tasks (e.g., Glanzer & Cunitz, 1966), which, in this experiment, occurred between the end of the experimental session and the time when the success-frequency question was answered.

Of course, these memory-based explanations for the success-frequency findings are only speculative and require formal testing. However, the extent to which our results appear to agree with the memory literature does suggest that success-frequency estimates in illusion of control studies have, to date, reflected memory of the number of obtained wins rather than inferences about how wins can be obtained.

Directions for future research

One direction for future research could involve testing competing explanations for our main result – the finding that the ‘ascending’ condition had higher associated inferred control levels than the ‘descending’ condition. Matute (1995) obtained a similar finding and interpreted it to mean that participants in the ‘ascending’ condition believed that they had learned the ‘correct’ response. An alternative interpretation is that experiencing a declining success rate in the ‘descending’ condition caused participants to accurately perceive that no learning was occurring. Testing Matute’s explanation would involve observing behavioural patterns over time, as Matute did in finding that participants in the ‘ascending’ condition were more likely to repeat the same response or response sequence during the last trials of the task. Analogously, in our experimental task, if Matute’s interpretation is correct, the ‘ascending’ condition should give rise to declining rates of player-profile change and kick-direction variability over time.

Our findings also raise questions regarding the illusion of secondary control. One issue is that the fine details of the factor analysis used to establish the illusion of secondary control as a separate construct differed slightly from those in the study by Ejova et al. (2010; see Appendix 4C). The task for future research is to adjust the wording of the perceived-control measure to form a measure of inferred primary and secondary control that can be applied consistently across studies. Since the illusion of secondary control was found not to vary as a function of success-slope, another task for future research is to identify other factors that might influence this variant of the illusion. The degree of choice available in the gambling task has been suggested as a possibility. Specifically, it has been suggested that greater opportunities for choice allow for a wider range of magical or superstitious beliefs to be applied in generating playing strategies (Rothbaum, Weisz & Snyder, 1982; Wohl & Enzle, 2002). For example, in our experimental task, the availability of a player profile choice option featuring famous soccer players allowed participants to select a ‘lucky’ player. Removing this feature or using less well-known players should, by this logic, lead to a reduction in perceived secondary control.

Future research could also set out to test our speculative claims about the memory effects underlying the observed pattern of success-frequency estimates across success-slope conditions. Specifically, one hypothesis was that an ‘over-under effect’ (the tendency to overestimate the baseline success-frequency because it was only 1/6) operated in all conditions. This claim needs to be verified by obtaining success-frequency estimates across different objective success frequencies within the soccer-themed task and observing (a) whether lower frequencies are consistently overestimated while higher frequencies are consistently underestimated, and (b) whether 1/6 is among the ‘lower’ (i.e., overestimated) frequencies. A second claim was that ‘recency effects’ (better memory for events late in the sequence) disappeared in the ‘ascending’ condition due to the time that elapsed between the end of the task and the presentation of success-frequency questions. This hypothesis can be tested by investigating whether the ‘ascending’ condition produces higher success-frequency estimates when questioning is immediate rather than delayed.

Appendices for Chapter 4

Appendix 4A: Measures and procedure

4A.1: Pre-experimental questionnaire

Drake Beliefs About Chance Inventory (DBC; Wood & Clapham, 1995)

<u>Illusion of Control scale (DBC-Primary)</u>

1. Wins are more likely to occur on a hot machine.
2. The more familiar I am with a slot machine game, the more likely I am to win.
3. It is good advice to stay with the same pair of dice on a winning streak.
4. Show me a gambler with a well-planned system and I'll show you a winner.
5. If a coin is tossed and comes up heads ten times in a row, the next toss is more likely to be tails.
6. There are secrets to successful slot machine, roulette and dice gambling that can be learned.
7. One should pay attention to lottery numbers that often win.
8. A good slot machine, roulette or dice gambler is like a sportsperson who knows winning plays and how to use them.
9. Some gamblers are just born lucky.
10. The longer I've been losing, the more likely I am to win.
11. I will be more successful if I have a system to play the slot machines.

<u>Superstition scale (DBC-Secondary)</u>

12. There may be magic in certain numbers.
13. I can improve my chances of winning by performing certain special rituals
14. There is useful information in my daily horoscope.
15. Playing slot machines is a form of competition between the player and the machine.
16. I believe that fate is against me when I lose.
17. A game of chance is a contest of wills between the game and the player.

18. When I take a test (or took them in the past) I use a lucky pen or pencil.

19. When I need a little luck I wear lucky clothes or jewellery.

20. I consider myself to be a superstitious person.

21. I like to carry a coin, charm or token when I'm doing something important.

22. I have a special system for picking lottery numbers.

Soccer Interest

To what extent are you interested in soccer? (0) Very strongly, (1) Strongly, (2) Mildly, (3) Very little, (4) Not at all

4A.2: Task instructions

Verbal and written instructions issued to participants upon arrival

“There has been some speculation about the nature of psychological responses to themed gambling tasks, such as slot machine games based on well-known board games or sports. This study is concerned with your impressions of a soccer-themed gambling task we have designed for use in future research on this issue. The task operates on exactly the same principles as a slot machine, but looks slightly different because it has been adapted for the university laboratory, a setting that lacks the lights, sounds, and social atmosphere of real gambling venues.

Participation in the experiment will involve completing a preliminary questionnaire about your gambling-related and soccer-related experiences, playing the computerised soccer-themed gambling game, and completing a questionnaire about your impressions of the gambling task.”

On-screen instructions presented after completion of the pre-experimental questionnaire

“You are now ready to play the soccer-themed gambling game itself! The game possesses the essential features of a slot machine game, but these features are embedded in a gaming environment that is thematically more interesting than standard slot machine games.

Here are the basic rules of the game... You will start the game with $5 worth of credit. In each round, you will be able to choose how much credit to bet on whether a goal (or a set of goals) will be scored by a soccer player shown on the screen. Apart from the bet amount, you will also be asked to choose a player profile and the direction in which the ball will be kicked."

4A.3: Post-experimental questionnaire

Inferred control

Supplementary yes/no strategy measure:

"Did your experience of the game suggest to you that you could draw on a strategy to produce goals when you needed them?

If yes, briefly describe your strategy."

Remembered success-frequency

Retrospective goals (for a random half of participants)

"As far as you can remember, what percentage of the shots you kicked over the course of the game resulted in goals?"

Retrospective misses (for a random half of participants)

"As far as you can remember, what percentage of the shots you kicked over the course of the game resulted in misses?"

Prospective

"If you were allowed to kick another 100 shots in the game, on how many of those shots do you think you would score a goal?"

4A.4: Post-experimental questionnaire: manipulation check

Item

As far as you can remember, what is the best way to describe the overall sequence of kick outcomes you experienced during the game?

- Wins were relatively evenly spaced out across rounds;
- Noticeably more wins occurred at the beginning;

- Noticeably more wins occurred during the middle rounds;
- Noticeably more wins occurred at the end;
- Noticeably more wins occurred at the beginning AND at the end.
- Other (please specify)

Findings

In the 'descending' condition, the correct answer of "Noticeably more wins occurred at the beginning" was offered by 78% of participants. In the 'ascending' condition, 55% reported experiencing most wins at the end, and 24% in the middle rounds. Among participants in the 'flat' condition, 42% correctly recalled that "wins were relatively evenly spaced across rounds" and 25 % reported the wins to have been concentrated in the middle rounds. In the 'U-shaped' condition, 47% reported seeing most wins in the beginning, 26% reported an even spread, and 15% correctly identified their sequence as having featured "more wins at the beginning AND at the end".

Appendix 4B: The experimental manipulation

Participants experienced one of three possible outcome sequences in each success-slope condition. In generating the ‘descending’ sequences, it was decided that the four 12-trial blocks comprising 48 trials would feature four, three, one, and zero wins, respectively. Numbers from one to 12 were then randomly generated without replacement to determine the exact position of the winning trials. Three different sequences were created in this way and Table 4B.1 shows one of them.

The ‘flat’ and ‘U-shaped’ sequences were created in a similar manner, subject to the constraint that ‘flat’ sequences would be characterised by two wins per 12-trial block, while the ‘U-shaped’ sequences would feature three wins in the first and last blocks, and one in each of the middle blocks. The ‘ascending’ sequences were obtained, simply, by flipping the ‘descending’ sequences.

Table 4B.1. An example of the outcome sequences experienced in the four success-slope conditions

	Success-slope condition			
	‘Descending’	‘U-shaped’	‘Ascending’	‘Flat’
Trials 1-12	LWLWLW LLWLLL	LWLLLW LWLLLL	LLLLLL LLLLLL	LLWLLL LLWLLL
Trials 13-24	LLWLWL LLWLLL	LLLLLL LLLWLL	LLLLLL WLLLLL	LLLWLL LLLLLW
Trials 25-36	LLLLLW LLLLLL	LLLLWL LLLLLL	LLLWLL LWLWLL	LLLLWL LLLLWL
Trials 37-48	LLLLLL LLLLLL	WLWLLL LLLLWL	LLLWLL WLWLWL	WLLLLL LLLLWL

Appendix 4C: Factor analysis and preliminary screening of inferred control measure

Before submitting responses on the inferred control measure ("To what extent would you use each of the following statements to describe the reason for your successes?") to a factor analysis, two preparatory steps were taken. First, responses were checked for sufficient variability, as reflected in the frequency of non-zero ratings. The distribution of responses is summarised in Table 4C.1 and is almost identical to that obtained in our earlier study (Ejova, Delfabbro & Navarro, 2010). On average, approximately 60 percent of the ratings provided for each statement were not zero. The newly-introduced 'Bet options' statement (9) was distinct in attracting non-zero ratings from 80 percent of participants.

The second preparatory step, also conducted in the pilot study, was a screening procedure aimed at identifying statements correlating with other statements due solely to inter-correlating zero ratings. The procedure is as follows. Starting with the statement that attracted the most zero ratings, select only those participants who did not provide a zero rating for that statement. If, in this select dataset, the Spearman correlations of the statement with other statements become largely non-significant, exclude the statement from the subsequent factor analysis. The application of this procedure led to the exclusion of the 'Chance' statement (15). While non-zero ratings on other statements correlated with ratings on a minimum of four statements ($p < .01$), non-zero ratings on this statement did not correlate with any statement ratings.

For the 14 retained statements, an examination of initial communalities led to the further exclusion of the 'Bet' statement (9) from the factor analysis. For the remaining statements, a Principal Axis Factoring (PAF) analysis was carried out upon ascertaining factorability (KMO = .94; Bartlett's test: χ^2 (78) = 2130.11, $p < .001$; initial communalities shown in Table 4C.2.). Various criteria for extracting factors (eigenvalues greater than one, point of inflection on the scree plot and parallel analysis[14]) suggested a two-factor solution (Hayton, Allen & Scarpello, 2004), so two factors were extracted.

[14] The parallel analysis was carried out using the `nFactors` package (Raiche & Magis, 2010) in *R* Version 2.15.0. *IBM SPSS Statistics 19.0* was used for all other analyses.

Table 4C.1. Distribution of responses to statements comprising the inferred control measure (N = 334)

	Statement	No. of participants providing an agreement rating of: 0 out of 10	1 to 4 out of 10	5 out of 10	6 or more out of 10
1.	I got better with practice.	156	84	44	50
2.	I learned how to predict the movements of the goalkeeper.	176	103	22	33
3.	My skill in playing the game	145	117	35	37
4.	Experience at playing computer games	150	87	43	54
5.	The kick directions I chose	91	93	58	92
6.	My knowledge of soccer	189	90	27	28
7.	I developed a logical strategy for playing the game.	114	96	46	78
8.	The player(s) I chose	115	93	52	74
9.	The bet options I chose	66	74	78	116
10.	I deserved to win.	157	75	39	63
11.	I've always been a lucky kind of person.	141	104	52	37
12.	A certain lucky way of playing just seemed to work for me.	130	113	45	46
13.	I took advantage of moments when my luck was good.	131	87	30	86
14.	I knew how to make luck go my way.	186	98	25	25
		10 out of 10	9 to 6 out of 10	5 out of 10	4 or less out of 10
15.	It was all chance	143[#]	116	47	23
Average:		139.3 (42%)	95.3 (29%)	42.9 (13%)	56.1 (17%)

[#] 21 of these Ss provided zero ratings on all other statements.

The factor loadings of statements following direct oblimin rotation (Costello & Osborne, 2005) are shown in Table 4C.2. In line with the pilot findings, statements relating to practice (1), skill (3), computer games (4), and strategy (7) clustered together in loading on a primary control factor (Factor 1). This factor also came to be defined by the ‘Goalkeeper’ (2) and ‘Player profile’ (8) statements, which had loaded on secondary control in Ejova et al. (2010). The newly-introduced statement about kick direction choices (5) also loaded on this factor, and the final statement comprising the factor was the ‘Soccer knowledge’ statement (5), which was excluded from Ejova et al.’s (2010) factor analysis because it attracted the highest number of zero ratings. Factor 2 corresponded to an inferred secondary control latent variable in consisting of the four luck-related statements (11-14) and the ‘Deserving to win’ statement (10). The two factors were strongly correlated (*r* = .73).

Table 4C.2. For the 13 retained statements of the inferred control measure, initial communalities and factor loadings and communalities after extraction produced by a PAF analysis with oblimin rotation (N = 344)

	Statement referring to:	Initial commu-nality	Factor loadings F1 Primary control	F2 Secondary control	Commu-nality
1.	Practice	.66	.99		.74
2.	Goalkeeper movements	.55	.78		.57
3.	Skill	.65	.72		.66
4.	Computer games	.52	.68		.54
5.	Kick direction	.37	.60		.37
6.	Soccer knowledge	.40	.57		.39
7.	Strategy	.40	.55		.37
8.	Player profiles	.36	.53		.34
10.	Deserving to win	.47		.84	.60
11.	Self as lucky person	.44		.69	.50
12.	Lucky play pattern	.49		.63	.54
13.	Lucky moments	.45		.58	.49
14.	Knowledge of luck	.56	.40	.41	.57
Variance accounted for after rotation:			46%	5%	
Cronbach's alpha:			.88	.84	

Note: Factor loadings <.3 are suppressed

Appendix 4D: Gambler's-fallacy-based strategies

Table 4D.1. Strategy descriptions of those who responded affirmatively to the post-experimental-questionnaire item, "Did your experience of the game suggest to you that you could draw on a strategy to produce goals when you needed them?" Gambler's-fallacy-based strategies are italicised. (N = 66)

	Described strategy
1.	*Use the smallest bet (10) for three or four trials and then use the 100 to win the credit.*
2.	*After you spend around $1 you win a kick. But each time you spend more, so even if you win, you will still end up losing money.*
3.	*Betting smaller bets during periods when there hadn't been a goal for a while, until there was a goal, and then increase bets.*
4.	*Change bet, change player, and go for random [kick direction] occasionally.*
5.	*Sometimes it worked just going for one side (e.g., the top right to score a goal) and eventually you would win using 100 credits to win 535 credits. So the losses were won back usually.*
6.	*Choose the same shot.*
7.	*Top right every time.*
8.	*Not really, but since most times there was no goal, after a long space of time without scoring, I upped the bet conservatively in the expectation that the people who design these things have to let you win sometimes.*
9.	*Don't choose the random kick direction; choose to kick in only one direction every time, then approximately every second or third kick you'll get a goal and you can bet more on the second and third but bet a little on the first kick.*
10.	*Go for the same spot over and over and eventually it will go in.*
11.	*I had two or three goal streaks. I guess I could stick with betting the lowest amount until I got a goal or two, then start betting 50 or 100.*
12.	*I think that once I changed players, I would score in the first two or three shots of the new player. I found that if I didn't change players for a while, I didn't score, so I changed players after every goal.*
13.	*I thought if I bet low for a few kicks the next I would bet higher and get a goal, but I think this was all just luck.*
14.	*I thought it was always best to start low, go easy on the money. Then later try higher amounts. I also tried to do random kicks.*

15. *I tried to reduce the amount I was betting after I had won for a few rounds so I wouldn't lose a lot since it was unlikely I would win twice in a row.*
16. *I would place a higher bet after 5-7 goals, as I thought a goal would most likely occur.*
17. *Invest 10 for the same direction three times and then invest 100 for this direction.*
18. *Keep kicking the same direction, regardless of misses.*
19. *Keep trying the same kick direction until you win.*
20. *Keep staying on the '1 goal in 2 trials' bet option with random kicking direction.*
21. *Choose Kaka; start small and increase bet; goalie weakest on top left but can surprise with change to top right.*
22. *Top corners seemed to result in more goals. If hit a dry streak, hit random a few times in a row.*
23. *Never stick to one particular formula. If Plan A doesn't seem to work out, try Plan B! I switched between betting on the next shot and on one goal in two shots".*
24. A certain player could score a goal in the left hand of the goals every second shot.
25. By changing the player profile.
26. I started using top left or top right because that's when I was scoring goals.
27. After several shots, choose "random" [kick direction].
28. Bet 100 credits three times in a row and pick a particular way to shoot that three times in a row.
29. Two times top right kick will lose; third time will be a goal.
30. Choose a strong player.
31. Choose the right down, then right up, the last may get score.
32. Choose Beckham?
33. Beckham scores more goals.
34. Cristiano Ronaldo top right.
35. At least with the Ronaldo profile, there didn't seem to be any point in shooting to the right or top right.

36. Playing with Ronaldinho, I felt there was a higher chance of him kicking a goal if I picked the top left corner as the kicking direction.
37. Right-footed players tend to curl the ball to the top left corner if on the left side of the goal. So, when kicking left side of goal outside the box [as in the task], use a player like Beckham and shoot to the top right-hand corner.
38. I thought the left sides seemed to do better than the right sides for goal shot options.
39. Use the best player.
40. Keep rotating the players and some players appear to be good at scoring by kicking in some directions.
41. It was more favourable to select kicks on goal on the left-hand side. Another factor was the penalty taker [player profile]. Kaka seemed to score more goals than the rest of the players. Ronaldinho did not score any.
42. Watch the keeper to kick the ball in the right place.
43. The higher the bet is, the higher the chance of scoring after a few shots in the same direction.
44. Beckham got more goals than the other players I used. Most goals happened lower left and right.
45. Try to use different patterns of shooting choices (first top left then top right; top left then bottom right; a few of random shooting or same direction of shoots for 2 to 3 times).
46. Deliberately kick in one direction, then in the next round kick in the complete opposite direction.
47. Kick up the top seemed to go in more than along the bottom.
48. Make two shots to the same angle and there is likely to be a goal.
49. Moving from sector [kick direction] to sector. If without score, change value of bet.
50. Kicking to the left and bottom directions produced goals.
51. Pay attention to the movement of goalkeeper.
52. The kicking tactics used by the four players to shoot goals – knowing these (i.e., knowing the players' style) can determine how to gamble.
53. Maybe there was some connection between the role of player designed in the game and the chance of winning the game. But it does not always happen.
54. Concentrate more.

55. This is not really a strategy for producing goals. I divided the potential winnings by how much it cost to play for each type of bet, to determine which bet was best to make.
56. Bet on one goal out of two kicks, as this option provided the best odds to win (approximately 1:5 return). If I can score one goal in less than 10 kicks, I will be winning money.
57. Choose to bet 40 credits because I think it gives more chance to win the prize.
58. The bet on 40 for one goal in two rounds is the best choice because I played several times on it and it seemed the chance is equal. It is worth choosing because you can get 127 on one bet.
59. I wanted to prove that the psychology department does not provide enough money to fund research, so I used bet options that had large but unlikely winnings on offer. Turns out, my hypothesis was proven.
60. Unsure really but I was trying to figure out some kind of strategy. However I am not convinced that it would have helped at all anyway.
61. When you are playing the cards, if you have a good memory, you will win easily.
62. Observe other players and be familiar with the game before playing it.
63. To aim for a goal in order to get back the credit.
64. It's all about luck.
65. Randomness.
66. Yes.

Appendix 4E: De-briefing

To cement and expand on a verbal de-briefing, participants were issued a brochure with the following information.

De-briefing: Some cautionary points about gambling

The soccer-themed-gambling game you played was, in many respects, similar to a slot machine game, although it clearly lacked many of the features of slot machine games in a realistic setting, including the pub or casino atmosphere, the special slot machine music, and the sound of coins being won on neighbouring machines. However, there is always the danger that even after taking part in a game of chance as basic as the one presented in this experiment, you could come to find gambling more attractive – particularly if, say, you found yourself winning more towards the end of the session (as though you had 'learned' something) or winning something at even intervals (as though chance was really being 'fair'). This sheet outlines a couple of facts about the nature of games of chance that should make you leave here convinced that there is *absolutely nothing* you can do to become more successful – that is, more likely to win money – at such games. In fact, frequent gambling can lead to nothing but loss of money.

Common misconceptions about gambling

Studies in which participants verbalised their thoughts while playing slot-machine-type games revealed that people tend to erroneously think that they can exert control over the outcomes of such games. This 'illusion of control' in relation to gambling outcomes has been observed not only among people with gambling problems, but also among people who gamble only recreationally. The illusion comes in two forms:

<u>(1) Illusion of natural control: The belief that there exist skills and strategies for increasing one's chances of success in gambling-related games</u>

When gambling, many people tend to devise skill-based strategies in an attempt to control the uncontrollable. Most commonly, players attempt to predict when the next win is due based on the preceding sequence of outcomes. On slot machines, for example, they believe that the occurrence of a long string of losses heralds a win because the random nature of the outcomes implies that there must be a fair degree of random alternation between wins and losses. Guided by this conviction, people playing slot machines tend to increase their bets after a series of losses, believing that in doing so they maximise the amount of the win that (they think) is due any second. The same type of reasoning motivates slot machine players to begin their gambling session on a machine that has not paid out much during the day. It is also why roulette players believe that the ball is highly likely to fall on a red number after falling on black numbers eight consecutive times.

Other strategies reported by slot machine gamblers include thinking that free spins mean something, thinking that near-misses mean something, and not playing on days when pub owners might tamper with machines to make them pay out less.

A popular explanation for why people develop these erroneous strategies in gambling contexts is that people have a natural capacity for learning and planning when looking for solutions to challenging problems. In most environments, solutions to the problems are available – just not immediately evident. Gambling environments, however, are very unique. They are intentionally structured so as to present humans with problems (that is, games) to which there are no solutions (that is, no strategies for ensuring success). This means that in gambling contexts the usually helpful ability to learn manifests itself as the erroneous illusion of control, causing people to try out various skill-based strategies for improving their performance when, in reality, performance is completely unrelated to personal skill.

Many explanations also exist for why people's strategies in gambling contexts so commonly revolve around the idea that 'chance is fair even in the short-term'. One explanation is that most of the cycles people encounter in life do come to an end. For example, the longer a rainy period continues, the closer a sunny period. Readings outlining the different theories are listed in the 'Further reading' section at the end of this document.

<u>(2) Illusion of supernatural control: The belief that luck/god is an ally that can be relied on to produce winning outcomes</u>

While some people succumb to the natural impulse to view gambling outcomes as being controllable through skill, many are prepared to acknowledge that gambling outcomes are chance-determined and, thus, not subject to skill-based control.

However, the latter group can fall into a different trap – the trap of thinking that, during gambling, the forces of chance are 'with them' because they were born lucky, because they deserve to win, because they said a prayer prior to gambling or because they are wearing their lucky socks. Slot machine players who entertain this conception of gambling may always play on one machine, considering it their 'lucky' machine. Roulette players who perceive chance as their ally may bet on favourite or lucky numbers.

According to an article by Atran and Norenzayan (2004; see 'Further reading') modern superstitious/religious beliefs are offshoots of beliefs humans have held for four million years (i.e., over the course of human evolution). The beliefs are likely to have evolved due to a combination of factors acting together – factors such as fear of death/illness, the tendency to react to every rustling of leaves as though it might signal the approach of a predator, and the tendency to hold separate theories about 'substances', 'plants', 'animals' and 'humans'.

Features of gambling environments that maintain people's misconceptions about gambling

Games of chance on slot machines and at casino tables are, in fact, designed to enhance players' perceptions of the game outcomes as being controllable through skill, alignment with supernatural forces, or both of these factors. For example, consider slot machine games and roulette:

- **Slot machines:** When playing on slot machines, players can choose how their screen looks, how fast the reels spin and how much money to bet in each round. Free spins are occasionally awarded, and many machines now feature 'bonus games'. Also, the reels are designed in such a way that many near-misses are experienced. This is done by making a symbol common on four reels, but not on the fifth. All of these game features provide ample opportunities for learning different playing rules, or finding 'lucky' playing options, even though, really, there are no rules for playing.
- **Roulette:** In many casinos, the winning numbers of previous rounds of roulette are shown on a screen near the roulette table. This suggests to players that studying the sequence of preceding outcomes is in some way related to success in the game.

Making available such a results summary, thus, only encourages players to put into practice the irrational strategy of determining what number or colour to bet on based on how often the number or colour has won in the past.

Overcoming the common misconceptions about gambling: two things everyone should know about games of chance

<u>Games of chance have a negative winning expectancy</u>

The winning expectancy in a game of chance corresponds to the amount of money that is, in the long term, redistributed among players (in the form of wins) from the pool of money that the players, as a collective, put into the game when placing their bets. For the individual gambler, the winning expectancy determines what he or she can gain from playing the game over a long period of time. Games in gambling environments have a negative winning expectancy. That is, they are designed in such a way that players who take part in them inevitably lose money as a group, and – for those who bet repeatedly – as individuals. The gambling industry generates profits by giving back less money than it collects. Back to our good old examples – slot machine games and roulette…

In South Australia, State law prescribes that slot machines should, on average, return as wins 85 to 87% of the money that is put in them. This means that, in the long run, players lose 15% of the money they put in. As an illustration, imagine that Luis has one million dollars that he is prepared to spend playing slot machines. Given that the winning expectancy in slot machine games is -15%, Luis should have roughly $850,000 left after putting one million dollars into the machines. If he then decides to play his $850,000, he will lose another 15% of that, and so on.

In roulette, the casino collects 5.26% of the money that is bet on a wheel that contains two zeros, and 2.7% of the money that is bet on a single-zero wheel.

The messages to take away based on this information about the negative winning expectancy:

- Players taking part in games of chance tend to believe that the greater the number of losses they experience, the closer they are to a win. In reality, however, time acts against the gambler. The winning expectancy in gambling-related games is always negative, which means that it is mathematically impossible for players who bet repeatedly to consistently recover or recuperate losses. **Regular gamblers inevitably lose more than they win.** It is only by playing very infrequently that one can actually avoid losing the amount of money prescribed by the negative winning expectancy.

- Awareness of the fact that there is a negative winning expectancy associated with gambling-related games should also limit the extent to which you may endorse the idea that consistent wins are possible if you take steps to align yourself with luck or god. **A person would have to have very tight control over luck and god in order to consistently win in a game that is designed to make you lose in the long run.**

<u>Games of chance are based on the principle of the independence of turns</u>

Predict the tenth outcome in the following sequence of coin tosses:

Tails
Heads
Heads
Heads
Heads
Tails
Heads
Tails
Tails
?

If you found yourself analysing the first nine outcomes even for an instant before making your prediction, you committed a logical error. The probability of Heads or Tails landing face up is always 50% (one in two). This probability is the same for every individual throw regardless of the outcomes of any preceding throws because the coin has neither a ‘memory’ of previous turns, nor an ‘intention’ to create a sequence of outcomes that looks ‘appropriately’ random. This ‘independence of turns’ means that an observer cannot make use of any kind of strategy in predicting the outcome of any particular turn. Actually, independence from preceding outcomes is what makes an outcome purely chance-determined or random.

The outcomes of gambling-related games are independent of each other in exactly the same way as the outcomes of coin tosses. In fact, if you think about it, betting on whether the next winning number on a roulette table will be black or red is equivalent to betting on the outcome of a coin toss. The probability of a black or red number winning is 50% and the outcomes are independent of each other because the table does not have any memory for preceding outcomes. Slot machines are also programmed in such a way that the outcomes of individual rounds are completely independent of each other. The various sizes of bets and the number of ways in which the combination of winning symbols can be obtained are set in accordance with the long-run winning expectancy of -15%. Within these parameters, outcomes are completely randomly generated. Every turn is a unique and final game in itself.

It is within the interests of the gambling industry to ensure that the outcomes of gambling-related games are fully chance-determined. If there actually were strategies for winning that could be detected through careful observation of the game's outcomes, the gambling industry's profits would be eroded by the wins of players who manage to discover the strategies. That is why it is actually not profitable for pubs and casinos to program the machines to pay out less on certain days. In other words, games in a gambling setting are purposefully designed in such a way that players do not need any intelligence or skill to participate. Players are encouraged to think that there is skill involved. That's how the gambling industry keeps them coming back. But, hopefully, after reading this, you will not be one those people!

The study you took part in

The study you took part in our laboratory consisted of a survey about slot-machine-related beliefs followed by a gambling session involving a soccer-themed slot-machine-type game.

You played a slot-machine-like game under one of four outcome sequence conditions before indicating the extent to which you thought game outcomes were controllable (in a natural and supernatural sense). The four conditions were as follows:

- An 'end' condition, where most wins occurred at the end of the session.
- An 'even' condition, where wins were evenly spaced across the session.

- A ‘beginning’ condition, where wins were concentrated at the beginning of the session.
- A ‘U-shaped’ condition, where wins were concentrated at the beginning and at the end.

Results showed that (natural) control ratings were highest in the ‘end’ condition, most likely because that condition made participants feel as though they had learned some way of playing. This perception of learning emerged despite there being **no objectively correct way of playing the game**.

Further reading

- Much of the material presented here was drawn from Ladouceur, Sylvain, Boutin and Doucet’s (2002) book, *Understanding and treating the pathological gambler*. The book provides an excellent, easily-readable introduction to theories of gambling and the therapies available for treating problem gambling.
- The first laboratory-based investigation of the illusion of control was by Ellen Langer and it was described in an article titled, *The illusion of control*, in the *Journal of Personality and Social Psychology*, *32*, 311–328 (1975).
- For various theories about why erroneous beliefs in the fairness of short chance sequences are so widespread, see:
  - Estes,W. K. (1964). Probability learning. In A.W. Melton (Ed.), Categories of human learning (pp. 88–128). New York: Academic Press.
  - Hahn, U., & Warren, P. A. (2009). Perceptions of Randomness: Why Three Heads Are Better Than Four. Psychological Review, 116, 454-461.
  - Tversky, A., & Kahneman, D. (1974). Judgement under Uncertainty: Heuristics and Biases. Science, 185, 1124-1131.
- The article about the evolution of beliefs in luck, god and other supernatural forces was by Scott Atran and Ara Norenzayan. It was titled, *Religion’s evolutionary landscape: Counterintuition, commitment, compassion, communion*, and published in *Behavioral and Brain Sciences*, 27, 713-770 (2004).

Useful phone numbers

<u>Gambling Helpline</u>

1800 060 757 (Freecall)

24 Hour, 7 Day, Free, Anonymous and Confidential Telephone Counselling, Information and Referral Service

Other gambling help services

- Relationships Australia (Break Even and Gamblers' Help): (08) 8223 4566
- Anglicare SA: (08) 8301 4200 (Western suburbs): 8256 2160 (other suburbs)
- OARS Gambling Support Service: (08) 8218 0700

CHAPTER 5: Paper 3

Erroneous gambling-related beliefs as illusions of primary and secondary control: a confirmatory factor analysis

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Abstract: A number of psychometric instruments have been developed to measure people's susceptibility to erroneous beliefs relating to gambling. Few of these have, however, been based on a conceptual framework that examines the relationship between different belief types and common processes underlying these beliefs. In this paper, we report the findings of a confirmatory factor analysis that examines the proposal that most erroneous gambling-related beliefs can be defined in terms of Rothbaum et al.'s (1982) distinction between 'primary' and 'secondary' illusory control, with the former being driven to a large extent by the well-known gambler's fallacy and the latter being driven by a complex of beliefs about supernatural forces such as God and luck. A survey consisting of 100 items derived from existing instruments was administered to 329 participants. The analysis confirmed the existence of two latent structures (beliefs in primary and secondary control), while also offering support to the idea that gambler's fallacy-style reasoning may underlie both perceived primary control and beliefs about the cyclical nature of luck, a form of perceived secondary control. The results suggest the need for a greater focus on the role of underlying processes or belief structures as factors that foster susceptibility to specific beliefs in gambling situations. Addressing and recognising the importance of these underlying factors may also have implications for cognitive therapy treatments for problem gambling.

Introduction

Erroneous beliefs about gambling have long been thought to play a role in the development and maintenance of problem gambling (e.g., Ladouceur et al., 2001; Walker, 1992b). The beliefs have been documented in therapy case studies, interview data, and transcripts of gambling sessions in which players verbalise their thoughts (Griffiths, 1994; Keren & Wagenaar, 1985; Ladouceur, Sylvain, Boutin & Doucet, 2002; Livingstone, Wooley & Borrell, 2006; Toneatto et al., 1997; Walker, 1992a). Based on this data, numerous surveys for measuring erroneous gambling-related beliefs have been developed. The surveys consist of largely erroneous statements about gambling (e.g., "My choices or actions affect the game on which I'm betting"), and an agreement rating is required for each statement. The most commonly used surveys are the *Drake Beliefs About Chance Inventory* (Wood and Clapham, 2005), the *Gamblers' Beliefs Questionnaire* (Steenbergh, Meyers, May & Whelan, 2002), the *Informational Biases Scale* (Jefferson & Nicki, 2003), and the *Gambling Related Cognitions Scale* (Raylu & Oei, 2004). These surveys have been not only validated within various populations (e.g, students, wider community, people who gamble), but also subjected to exploratory factor analysis to gain insight into categories of erroneous gambling-related beliefs.

Central to all of the gambling-beliefs surveys is the concept of 'illusory control'. Most commonly ascribed to Langer (1975), this bias refers to the tendency for people to over-estimate the amount of control they believe they can exert in chance-determined situations. In Langer's view, the illusion occurs as a result of the confusion of chance and skilled activities in chance activities characterised by particular situational factors, including the availability of choice, practice and physical involvement. In a subsequent literature review by Rothbaum, Weisz and Snyder (1982), illusory control was divided into two categories: 'primary' and 'secondary'. Primary control relates to strategies aimed at physically changing the game environment, whereas secondary control involves attempts to influence outcomes through alignment with higher forces such as luck and God. In general this distinction has not been recognised in most of the factor solutions developed in gambling-beliefs surveys, although the two sub-scales of Wood and Clapham's (2005) survey appear, in general terms, to correspond to the two dimensions of illusory control postulated by Rothbaum and colleagues.

Conceptual complexities

Although the illusion of control has often been referred to in factor analytic gambling-beliefs studies, other belief categories have also been considered. One of the most common of these is the gambler's fallacy, a belief about the sequencing of chance-based outcomes. Specifically, this is the belief that random sequences tend to self-correct even in the short-term, producing a 'head' after a series of 'tails' in a coin toss game, a 'red' after a series of 'blacks' in roulette, and a win after a series of losses on slot machines (Nickerson, 2002; Oskarsson, Van Boven, McClelland & Hastie, 2009). The fallacy is commonly expressed in behaviours such as the seeking out of slot machines that are 'due' for a win (e.g., "One's chances of winning are better if gambling on a [slot] machine that has not paid out in a long time"; Jefferson & Nicki, 2003).

In general, the gambler's fallacy and the illusion of control have been discussed as separate belief categories in a number of factor analyses. However, a potential difficulty with this approach is that many of the beliefs relating to systems and strategies in gambling (often considered instances of the illusion of control) are likely to be related to the gamblers' fallacy. For example, people who have a strategy for picking machines, knowing when to stop playing, or which numbers to pick in roulette or lotteries will often refer to outcomes being more (or less) likely because of previous sequences of events (e.g., Livingstone, Wooley & Borrell, 2006). As a result, there is a danger of a conceptual confusion between items relating to illusory control and the gambler's fallacy in existing survey instruments. Conceptually, it may be that correlations between items relating to various strategies for gambling may be explained by the very strong influence of gambler's-fallacy-style reasoning.

Another potential difficulty in gambling-beliefs surveys relates to the concept of luck. In the wider literature on gambling and in introductions to gambling-beliefs survey studies, it is often implied that luck is a supernatural force with which players attempt to engage through rituals and objects (e.g., lucky charms; Henslin, 1967; Joukhador, Blaszczynski & Macallum, 2004; Toneatto, 1999). Appealing to luck in this way is a form of illusory secondary control under Rothbaum et al.'s (1982) definition. However, it is evident that luck is a more complex concept. Wohl and Enzle (2002, 2009) have, for example, also argued that people believe luck to be a stable personal quality, possessed by individuals to various degrees. Luck may also be linked to the gambler's fallacy in that those who subscribe to the fallacy may reason that luck comes in cycles. Indeed, people have reported believing that a skilled player is one who is able to know when their luck is 'in season' and who can anticipate when luck is no longer available (Keren & Wagenaar, 1985).

Given complexities of this nature, we argue that there is a need for greater conceptual thinking relating to the design of gambling-related belief measures. At present, most of these measures are set out in the form of a typology, often without any overall underpinning conceptual framework. Little attempt is made to examine the conceptual relationship between different types of beliefs (e.g., the illusion of control, beliefs about luck and the gambler's fallacy). In our view, it is important to: (a) distinguish between the two forms of illusory control, (b) understand to what extent broader biases such as the gambler's fallacy influence more specific gambling-related beliefs, and (c) understand whether items relating to the gambler's fallacy can easily be distinguished from measures of illusory control. Such conceptual issues are important in determining the construct validity of measures and the potential belief structures that should be addressed in treating problem gamblers.

Our interest in this topic is informed by recent developments in cognitive science, most notably an emerging literature that has drawn attention to the important role played by existing general belief structures in influencing how people might respond to situations, including gambling situations. In other words, rather than seeing instances of the illusion of control as merely the result of situational factors (choice, personal involvement, etc.) as Langer suggested, it is proposed that erroneous beliefs may result from the interaction between situational factors and existing belief structures. Not only can existing belief structures cause particular situational factors to be noticed, but apparent situational factors can be interpreted in light of the structures (Harris & Osman, 2012; Murphy & Medin, 1985). For example, in relation to the illusion of secondary control, it is likely that there are broader belief structures that make people susceptible to beliefs of this nature. As Atran and Norenzayan (2004) point out, three broad interconnected belief structures about supernatural beings are observed across cultures and mostly likely to be by-products of the evolution of adaptive cognitive faculties. These are beliefs in supernatural agents (e.g., gods, ghosts, luck), beliefs in the power and omniscience of these agents with regard to important events (e.g., death and calamity), and beliefs about rituals directed at the agents (e.g., wearing lucky socks).

Other general belief structures (again, very likely evolved) are likely to underlie people's susceptibility to illusions of primary control. However, whereas the illusion of secondary control may be influenced by a structure of beliefs about supernatural entities, the illusion of primary control must be the product of belief structures relating to non-supernatural (i.e., natural/physical) phenomena. We propose that, in games of chance, the gambler's fallacy is a particularly relevant general belief structure. It is general in that it has been argued to be unavoidable in games of chance due to the operation of the representativeness heuristic (Tversky & Kahneman, 1974).

A summary of the implications of these conceptual complexities for emerging belief categories in gambling-beliefs surveys is presented in Figure 5.1 and Table 5.1. The illusions of primary and secondary control are presented as belief categories expressed through agreement with the survey statements. Sub-categories of survey statements are shown as arising, at least in part, from the gambler's fallacy and/or supernatural beliefs as defined by Atran and Norenzayan (2004). The joint influence of these broader belief structures results in the belief that luck appears and disappears in cycles. Otherwise, the gambler's fallacy gives rise to sub-categories of the illusion of primary control while general supernatural beliefs give rise to sub-categories of the illusion of secondary control. We elaborate on the sub-categories below, with example statements being presented in Table 5.1.

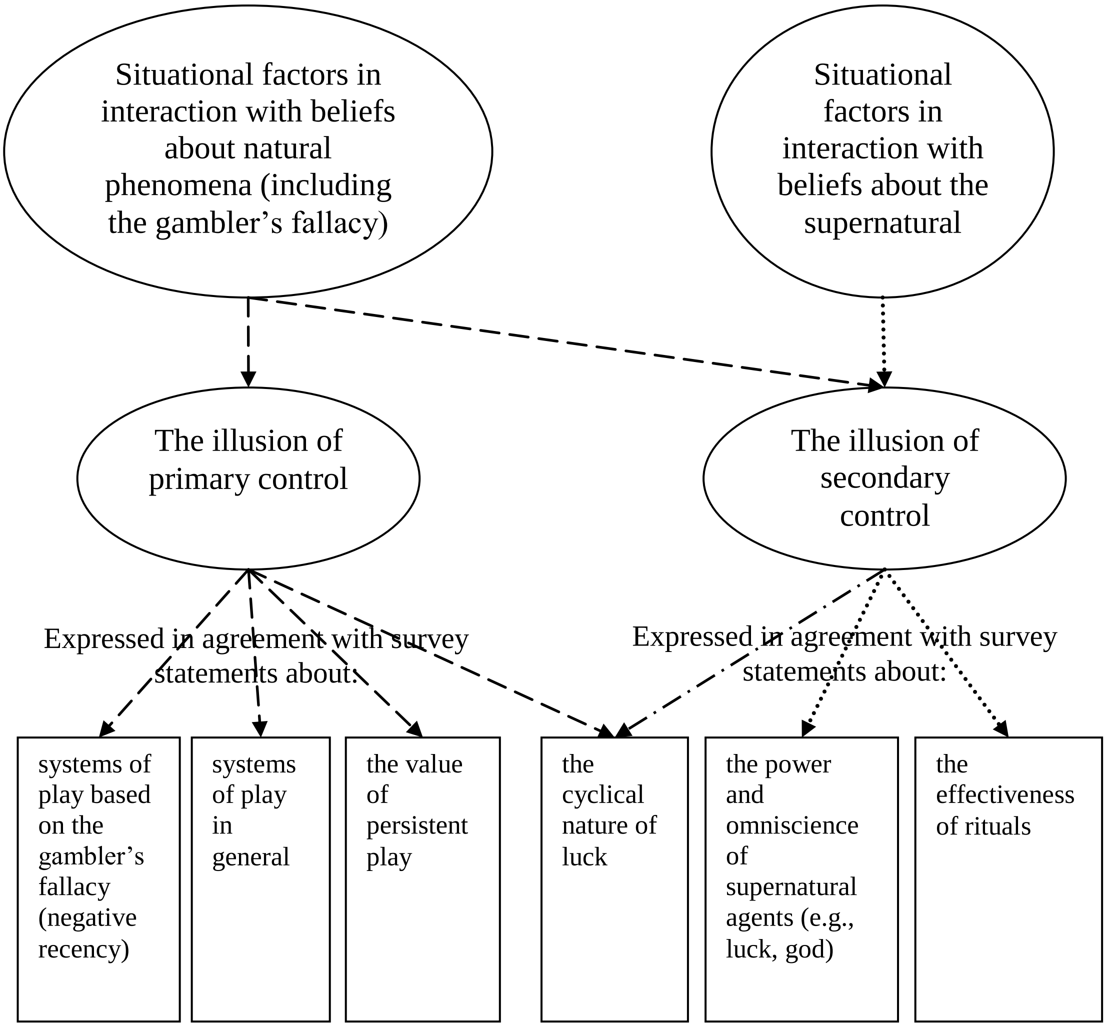


Fig 5.1. A proposed basis for distinguishing between the illusions of primary and secondary control: the general belief structures that give rise to them. Notably, in a gambling context, where luck is a particularly relevant supernatural agent, the gambler's fallacy contributes to shaping the belief that luck is cyclical.

Table 5.1. Examples of statements from sub-categories of the illusions of primary and secondary control

Illusion of primary control

Beliefs in 'negative recency' strategies
- If I'm experiencing a losing streak, the thought that a win has to be coming soon keeps me gambling.[1]
- I should keep the same bet even when it hasn't come up lately because it is bound to win.[2]
- Sometimes I feel that I can keep winning because I have learned to predict the next random, new thing the machine is going to do.[3]

Beliefs in 'systems of play' (i.e., strategies generally)
- Show me a gambler with a well-planned system and I'll show you a winner.[4]
- I know I can win if I follow my strategies.[5]

Beliefs in a 'persistence' strategy
- If I continue to gamble, it will eventually pay off and I will make money.[2]
- Those who don't gamble much don't understand that gambling success requires dedication and a willingness to invest some money.[2]

Illusion of secondary control

Beliefs in the 'power and omniscience' of supernatural agents
- I believe that fate is against me when I lose.[4]
- Some gamblers are just born lucky.[4]

Beliefs in 'ritual' appeals to supernatural agents
- There are certain things I do when I am betting (for example, tapping a certain number of times, holding a lucky coin in my hand, crossing my fingers, etc.) which increase the chances that I will win.[2]
- I can improve my chances of winning by performing special rituals.[4]

Belief that 'luck is cyclical'
- There are times that I feel lucky and thus gamble those times only.[1]
- It is good advice to stay with the same pair of dice on a winning streak.[4]

[1] The Informational Biases Scale (Jefferson & Nicki, 2003)
[2] Gamblers' Beliefs Questionnaire (Steenbergh et al., 2002)
[3] Newly-written for this study
[4] Drake Beliefs About Chance Inventory (Wood & Clapham, 2005)
[5] Thoughts and Beliefs About Gambling Questionnaire (Joukhador, Maccallum & Blaszczynski, 2003)

Operationalising the illusion of primary control

With respect to perceived primary control, an inspection of existing gambling-beliefs survey items points to three principal sub-categories, all potentially reflecting the gambler's fallacy in some way. The first consists of strategies arising directly from the fallacy; that is, directly from the '*negative recency*' expectation that, in games of chance, the most recent outcome types will fail to repeat (Oskarsson et al., 2009). Strategies in this category include waiting for a win that is due, betting progressively higher amounts on one colour in roulette in expectation that the colour will be the winning one eventually, and alternating between colours in line with expectations of what outcome the random roulette wheel will produce next. Use of the two latter strategies has been observed in field settings (Walker, 1992b) and empirically demonstrated in a laboratory roulette game (Ayton & Fischer, 2004).

A second set of statements in gambling-beliefs surveys contain references to *systems of play* (i.e., strategies) more generally. Since the gambler's fallacy is central to human (or, at least, Western) concepts of chance, it is possible that many strategies in gambling are informed by the fallacy. However, it is possible that playing systems are additionally informed by beliefs less general than the gambler's fallacy – beliefs about specific situational aspects of the task. Some of these situational factors were identified by Langer. For example, the free spin feature on slot machines, a choice and physical-involvement factor in Langer's terms, gives rise to numerous strategic beliefs (Livingstone, Wooley & Borrell, 2006). Another way of defining these more-situation-specific beliefs is as rules for playing acquired through learning, problem-solving, or conditioning (e.g., Anderson, 1990; Skinner, 1948).

The third natural sub-category is a set of beliefs about the effectiveness of a *persistence* strategy in gambling. It follows from the gambler's fallacy that, after a series of losses, persistence in playing on a particular chosen option or slot machine makes a win imminent in the short-term. However, the belief in an imminent win can also proceed from a general adaptive sense of optimism (Cummins & Nistico, 2002), and from a feeling of entrapment in a losing investment (Walker, 1992b). Overall, then, the illusion of primary control expresses itself in three belief categories, shaped by the gambler's fallacy, learning and motivational factors.

Operationalising the illusion of secondary control

Beliefs constituting the illusion of secondary control in a gambling context appear to fall into the sub-categories prescribed by the existing characterisation of supernatural beliefs (Atran & Norenzayan, 2004). Table 5.1, once again, provides examples of representative survey statements. The first sub-category of supernatural control beliefs pertains to the *omniscience and power* of supernatural agents. With regard to one supernatural agent, luck, the fact that people believe it to be influential in important life events (e.g., escape from negative consequences) has even been demonstrated empirically (Wagenaar & Keren, 1988). Also indicative of belief in the omniscience and power of luck is the belief that luck is a personal quality (e.g., Wohl & Enzle, 2009). This belief is consistent with the general belief that omniscient divine agents are inclined towards rewarding 'good' people (Atran & Norenzayan, 2004).

The second sub-category refers to *ritual* appeals to supernatural agents. Sociologists Henslin (1967) and King (1990) made note of the abundance of rituals and lucky charms in craps and bingo. For example, Henslin observed that, since dropping the dice in craps is considered a bad omen, "without exception, each shooter, after dropping the dice, rubs both dice on the ground or playing surface" (p. 323)[15].

The third sub-category of illusory secondary control consists of variations on the belief that the supernatural agent luck is *cyclical*. As Keren and Wagenaar (1985) reported in summarizing interviews with 150 blackjack players:

> Most of our subjects (some of them explicitly) perceived luck as having a wave form. The art of the game is to catch the crest of the wave, that is, the lucky periods. (p. 152; see also Duong and Ohtsuka (2000) and King (1990))

On the one hand, believing in a cyclical luck implies believing that luck is an agent – an entity capable of varying its intentions, or 'moods'. In this sense, the belief proceeds from the general supernatural beliefs structure. At the same time, the belief proceeds from the gambler's fallacy in implying that runs of positive (and negative) outcomes are bound to end in the short-term. Notably, cyclical properties tend to be

[15] While many rituals in gambling contexts may result form broader supernatural beliefs, others might be more situation-specific in arising through simple conditioning processes (Jahoda 1969; Skinner 1948). In other words, gambling rituals and beliefs in their effectiveness could arise through the same conditioning processes as some 'systems of play' (instances of illusory primary control). How learning and conditioning might have been reflected in the findings of this study is considered in the Discussion.

attributed to luck and not other supernatural agents (e.g., God, Fate). This could be due to the fact that beliefs about luck are particularly relevant to gambling and therefore more likely to be influenced by a gambling-related belief structure – the gambler's fallacy. Beliefs in the cyclical nature of luck, thus, appear to be shaped by supernatural beliefs and the gambler's fallacy simultaneously.

The present study

This study aimed to determine whether a psychometric analysis of a comprehensive gambling-beliefs survey could reveal primary and secondary illusory control constructs with their respective sub-categories. The survey consisted of 100 statements, largely from existing surveys. Statements were adapted to refer specifically to a purely chance-based form of gambling – slot-machine play. In light of a well-documented trend for participants to disagree with most erroneous survey statements about gambling, participants were selected in such a way various levels of slot machine gambling experience were represented. People who gamble regularly were expected to be more likely to agree with statements, thereby providing variability in responses. Each of the belief sub-categories described above was expressed in terms of a unique set of statements. For example, degree of belief in the 'omniscience and power' of supernatural agents was calculated by averaging agreement ratings for the sample statements in Table 5.1 and the statements: "Following lucky signs can help me win", "Bad vibes from people around me cause me to lose", "I make the right choice because I'm generally lucky", "It's possible for the good or bad luck of other players to rub off on me", "I have the psychic ability to predict a winner", and "There is useful information in my daily horoscope".

Confirmatory factor analysis (CFA) was used to determine whether relationships between the belief sub-categories could be accounted for by higher-order primary and secondary illusory control constructs. In CFA, models are fitted to a matrix of covariances between observed (i.e., measured) variables, termed 'indicators'. Higher-order 'latent', or unobserved, factors predicted by the model can then be derived through multiple regression (see, for example, Kline, 2010). In our model, the belief sub-categories served as the indicators, and Figure 5.2 outlines model predictions regarding latent constructs. Beliefs in 'negative recency', 'systems of play', and 'persistence' were predicted to be indicators of the illusion of primary control.

Meanwhile, the illusion of supernatural control was predicted to express itself in beliefs in the 'omniscience and power' of supernatural agents, as well as in beliefs about 'rituals'. Beliefs about 'the cyclical nature of luck' were predicted to be a further expression of the illusion of secondary control, but also an expression of the illusion of primary control. Overall, the study is geared at providing a much-needed conceptual framework for refining gambling-beliefs surveys.

Method

Design

The data were drawn from the survey component of a larger study in which a laboratory gambling session was attended two weeks after survey completion.

Participants

There were 329 participants[16] (140 males), with a mean age of 24.8 (*SD* = 11.88). Among them were members of the general community, first-year Psychology students at the University of Adelaide, and other students at the university. Participation was only open to people who (1) were over the age of 18, (2) had gambled at a licensed venue at least once previously, and (3) were not in treatment for gambling-related problems. Recruitment processes were geared at ensuring that various levels of slot-machine gambling experience were represented. The end result was that, in the 12 months preceding participation, 13.7% of participants had not played on slot machines at all, 46.5% played a few times but not regularly, 14% played approximately once a month, 17.6% played two to three times a month, and 8.2% played weekly or more often.

[16] Of an original 330 participants, one was removed after providing the same answer to all survey items.

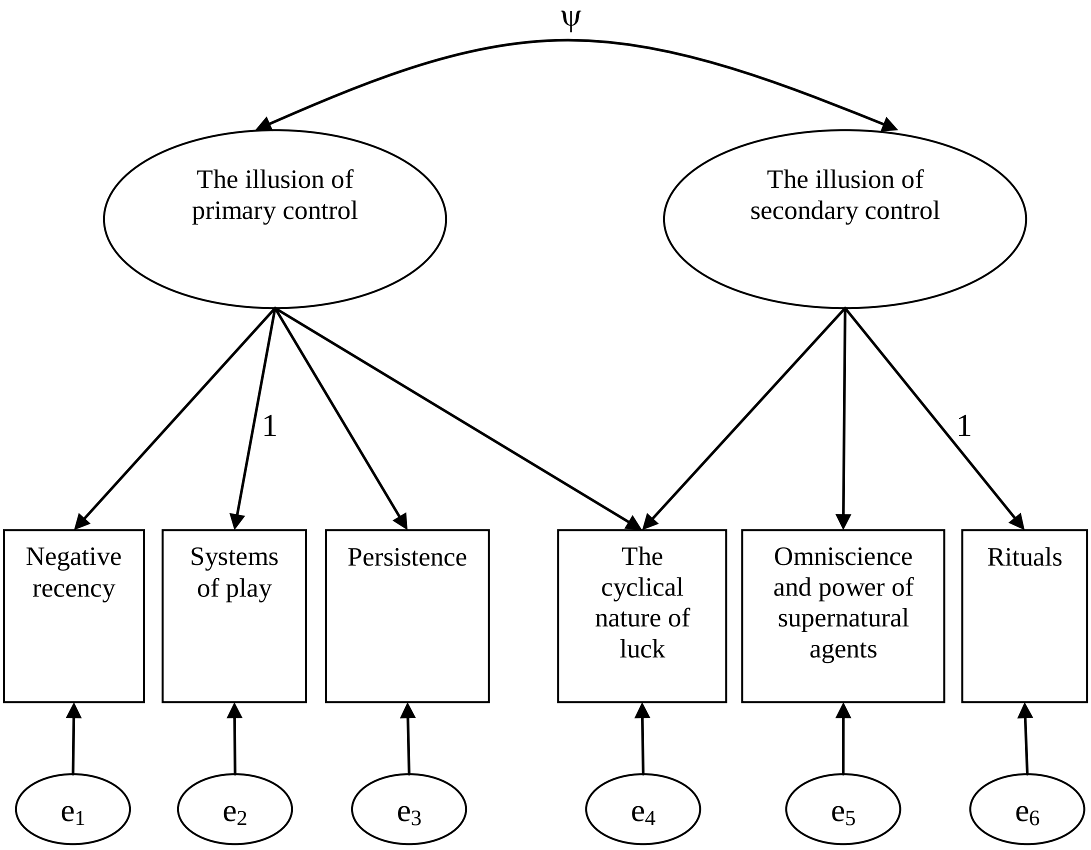


Fig 5.2. The CFA model of erroneous gambling-related beliefs, based on the proposed definition of primary and secondary illusory control. The six belief sub-categories are indicator variables, while the two forms of the illusion of control are higher-order latent variables.

Measures: Slot-machine beliefs survey

Apart from demographic questions, a question regarding degree of involvement in various forms of gambling in the past 12 months, and a Problem Gambling Severity Index (Ferris & Wynne, 2001), the survey contained 100 statements describing beliefs about slot-machine gambling. The statements are presented in Appendix 5A. For each statement, agreement was rated on a seven-point Likert scale, anchored at (-3) Strongly disagree, (0) Neither agree nor disagree, and (3) Strongly agree.

The survey was designed to incorporate as many existing surveys as possible in their entirety without substantial overlap between items. To this effect, two surveys and a scale were included in full. These were the Drake Beliefs About Chance Inventory (Wood and Clapham 2005; 22 items), the Gamblers' Beliefs Questionnaire (Steenbergh et al., 2002; 21 items[17]), and the Predictive Control Scale of the Gambling-Related Cognitions survey (Raylu & Oei, 2004; 6 items).

In the interests of including references to a wide variety of erroneous strategies, the complete surveys were supplemented by items selected from other existing surveys (17 items). Seventeen new items were also written to reflect additional experimental or observational findings, listed in Appendix 5A.

A final objective was to include a broader range of negatively-worded (i.e., objectively correct) statements, since there was only one such statement in the complete surveys. Eight negatively-worded items were sourced from existing surveys and nine were newly-written. Notably, all negatively-worded items were reverse-scored.

Procedure

Members of the general community who played slot machines regularly (once a month or more often) were recruited through an advertisement in a local newspaper. First-year Psychology students who met the basic participation requirements (see 'Participants') were recruited through a departmental research participation website. All other participants were students from other departments at the university who

[17] Two items from this survey were excluded because they did not express erroneous beliefs: "Gambling is the best way for me to experience excitement", "When I lose at gambling, my losses are not as bad if I don't tell my loved ones".

responded to poster advertisements around campus. Community and wider-university participants were reimbursed with a department store voucher, while the first-year Psychology students received course credit.

All advertisements directed potential participants to a website where the larger study was explained and the survey could be completed online. Alternatively, participants could contact the researcher (first author) with questions and requests for a posted hardcopy of the survey.

In the online version of the survey, the order of the 100 erroneous statements was randomised for each participant. Participants opting to complete hardcopies received one of three versions, each with a different random ordering of the items.

De-briefing occurred by post or e-mail at the end of data collection. De-briefings contained a copy of the survey, emphasised the erroneous nature of the survey's positively-worded statements, and encouraged participants to contact the researcher if they were unclear about why any particular statement was erroneous.

Results

Fitting the described CFA model of relationships between sub-categories of the illusions of primary and secondary control (Figure 5.2) required a number of steps. After the removal of problematic survey statements, the model's indicators, measures of the belief sub-categories, could be constructed. The model was then fitted, and models without key features of the proposed model were tested as a follow-up.

Removal of weak items

As recommended by some authors (Hooper, Coughlan & Mullen, 2008; MacCallum, Widaman, Zhang & Hong, 1999), measurement error was reduced by removing items that did not correlate substantially with most other items. Specifically, items that correlated with 60 or more other items at a magnitude of less than .3 were identified for removal[18]. There were 27 such items. Among them were 14 of the 17 negatively-worded items, so the remaining three negatively-worded items were also removed, leaving a total of 70 items for further analysis. Removed items are identified in Appendix 5A.

Measures of belief sub-categories

The retained statements were grouped according to which belief sub-category (‘negative recency’, ‘rituals’ etc.) they reflected. Table 5.2 lists the items selected to represent each sub-category. Measures of agreement with each sub-category (i.e., the indicators in the CFA model) were calculated by averaging the agreement ratings for constituent items (DiStefano, Zhu & Mindrila, 2009). For two participants who accidentally omitted some items when filling out hardcopies of the survey, sub-category scores were calculated using a reduced set of items.

For each sub-category score, Table 5.2 presents means, standard deviations, and distributional information (skew and kurtosis). The Cronbach’s alpha coefficients presented in the table imply internal consistency among the items comprising each measure. As Table 5.3 shows, however, almost all pairwise score correlations were greater than .80, suggesting that the measures had poor discriminant validity. This issue was addressed through the fitting of an alternative theoretically meaningless CFA model (see below).

[18] The value of .3 was chosen because correlations of .3 mean that less than 10% of variance is shared between items. The cut-off point of 60 such correlations was set based on the inspection of the items containing various amounts of low correlations. Items with 60 or more problematic correlations appeared qualitatively unrelated to most survey items. For example, the item “If a coin is tossed and comes up heads ten times in a row, the next toss is more likely to be tails” lowly correlated with 65 items and appeared to be a sensible candidate for removal because it does not refer to slot machine gambling.

Table 5.2. Belief sub-categories: constituent items, descriptive statistics, distributional information and Cronbach's alpha

	Constituent items (Appendix 5A)	*M* (*SD*)	Distributional information		Cronbach's alpha
			Skew.	Kurt.	
Negative recency	1-10	-1.1 (1.11)	-.01	-1.00	.87
Systems of play	11-41	-1.1 (1.01)	0	-.86	.95
Persistence	42-46	-1.6 (1.09)	.53	-.52	.77
Cyclical nature of luck	47-54	-1.2 (1.07)	-.02	-.90	.84
Omniscience and power	55-62	-1.3 (1.13)	.13	-1.03	.83
Rituals	63-70	-1.4 (1.20)	.24	-1.18	.87

Table 5.3. Pearson correlations between belief sub-category scores

	Neg. rec.	Systems	Persist.	Cyclical luck	Omnisc.
Systems of play	.87				
Persistence	.72	.77			
Cyclical nature of luck	.84	.86	.71		
Omniscience and power	.82	.84	.72	.84	
Rituals	.72	.74	.63	.75	.83

All $p < .001$.

Model fit

The CFA model shown in Figure 5.2 was fitted using maximum likelihood estimation in the `sem` package (Fox, Nie & Byrnes, 2012) in R version 2.15.2. All fit indices indicated good fit ($\chi^2(7) = 5.75$, $p = .56$; RMSEA = 0, CI_{90} [0, .06]; SRMR = .006; CFI = 1; BIC = 87)[19]. Standardised and unstandardised parameter estimates are presented in Table 5.4.

Table 5.4. Standardised and unstandardised coefficients for the fitted CFA model

	β	*B*	*SE*
Illusion of primary control → Negative recency	.92	1.00	
Illusion of primary control → Systems of play	.95	.94	.03
Illusion of primary control → Persistence	.80	.86	.04
Illusion of primary control → Cyclical luck	.66	.71	.09
Illusion of secondary control → Cyclical luck	.26	.26	.09
Illusion of secondary control → Omnisc. and power	.97	1.07	.04
Illusion of secondary control → Rituals	.85	1.00	
e_1 → Negative recency	.16	.20	.02
e_2 → Systems of play	.10	.11	.01
e_3 → Persistence	.35	.43	.04
e_4 → Cyclical luck	.17	.20	.02
e_5 → Omnisc. and power	.06	.08	.02
e_6 → Rituals	.27	.39	.04
Ψ (Latent construct correlation)	.93	.96	.09

R^2 for indicators: Negative recency: .84, Systems of play: .90, Persistence: .64, Cyclical nature of luck: .83, Omniscience: .94, Rituals: .73.

Alternative models

Aspects of the model were tested further by examining whether their removal or modification reduced model fit. Among the tested components was the prediction that beliefs about the cyclical nature of luck are an indicator of both types of illusory control. The test involved fitting a simpler model in which beliefs in the cyclical nature of luck were an indicator of the illusion of secondary control only. Obtained fit indices suggested that this model had a poor fit ($\chi^2(8) = 39.64$, $p < .001$; RMSEA = .11, CI_{90} [.08, .14]; SRMR = .016; CFI = .99; BIC = 115). A model in which beliefs in the

[19] Mardia's tests of multivariate skew and kurtosis (Mardia, 1970; Ullman, 2006), conducted using the `psych` package (Revelle, 2012), indicated violation of the multivariate normality assumption ($b_{1,p}$ = 2.4, skew = 131.43, $p < .001$; $b_{2,p}$ = 52.97, kurtosis = 4.6, $p < .001$). However, the effect of this violation is inflation of the χ^2 statistic (Curran, West & Finch, 2006), which was still non-significant in this case.

cyclical nature of luck were an indicator only of the illusion of primary control also fit slightly worse than the original model ($\chi^2(8) = 12.86$, $p = .12$; RMSEA = .04, CI_{90} [0, .08]; SRMR = .009; CFI = .99; BIC = 88).

A further assumption of the model is that beliefs in systems of play pertain only to natural systems, and not supernatural ones (e.g., rituals). The assumption was tested by fitting a model with a hypothesized additional relationship between the illusion of secondary control and the 'systems of play' score. Incorporating this relationship did not improve model fit ($\chi^2(6) = 4.51$, $p = .60$; RMSEA = 0, CI_{90} [0, .06]; SRMR = .006; CFI = 1; BIC = 91), implying that 'systems of play' are commonly understood to refer to conventional strategies rather than rituals.

The observed high correlation between the model's latent constructs, the illusions of primary and secondary control ($\beta\psi = .92$; see Table 5.4), necessitated the testing of a model in which these constructs were amalgamated into a single latent construct. Again, however, the fit of this modified model was poor ($\chi^2(10) = 63.88$, $p < .001$; RMSEA = .13, CI_{90} [.10, .16]; SRMR = .023; CFI = .97; BIC = 128).

Finally, in light of the poor discriminant validity of the belief sub-category measures (see Table 5.3), we tested the possibility that any equivalent model could capture the relationships between them. The fitted equivalent model featured two latent constructs, L1 and L2. 'Negative recency', 'Omniscience and power', 'Rituals' and 'Systems of play' served as indicators of L1, while L2 was expressed in terms of the other two sub-category scores and the shared indicator, 'Systems of play'. The parameter-value search for the model failed to converge in 5000 iterations, providing evidence of non-equivalence among the sub-category measures.

Discussion

The aim of this study was to examine the construct validity of a conceptual model that postulates that measures of gambling-related beliefs converge around two broader belief structures relating to the illusion of control. The first of these structures, primary control, is postulated to involve behaviours and beliefs based, to a large extent, on the gambler's fallacy. A second construct, secondary control, is assumed to involve behaviours and beliefs relating to general beliefs about supernatural agents and forces.

In light of these assumptions, six sub-categories of beliefs were defined and measured, and a CFA model of latent primary and secondary illusory control constructs relating the sub-categories was specified. On the whole, it was found that model predictions about the relationships between belief sub-categories were supported.

Our results support the earlier work of Rothbaum, Weisz and Snyder (1982), who argued that the illusion of control is not a one-dimensional construct. The results are also consistent with an earlier study by Ejova, Delfabbro and Navarro (2010), who provided evidence of the illusion's bi-dimensionality using a multi-item perceived control question presented after experience with a laboratory gambling task. The question consisted of 13 statements, each rated form 0 to 10 in terms of the degree to which it might have accounted for experienced wins. Apart from "It was all chance", the statements included, (1) "My skill in playing", (2) "I developed a logical strategy", (3) "I deserved to win", and (4) "I took advantage of moments when my luck was good". Factor analysis revealed a statement cluster consisting of statements such as 1 and 2, and a statement cluster consisting of statements such as 3 and 4.

The present findings extend this work by providing evidence for an explanation of *why* the illusion of control has two dimensions. Specifically, the CFA model's good fit serves as evidence for the proposal that one dimension (secondary) is the result of general beliefs about supernatural agents, whereas the other (primary) is the result of non-supernatural beliefs, including the general gambler's fallacy.

Most research on the illusion of control has followed Langer's (1975) lead in seeking to identify situational factors that give rise to what is assumed to be a unidimensional effect: an over-estimation of personal skill. We argue that the effect is likely to be more complex than this. For example, Wohl and Enzle (2002) found that, prior to a lottery drawing, participants who were allowed to choose a lottery ticket instead of simply being assigned one by a computer expressed greater confidence of winning. Our CFA results suggest that a person allowed to choose her lottery ticket might feel more confident of winning because she was able to choose numbers that haven't appeared for some time, or because she was able to choose her 'lucky' number. More generally, our findings imply that the same situational factor can give rise to different kinds of illusory control, depending on what pre-existing beliefs are applied in reasoning about the factor.

In light of the explanation of the illusion of control advanced in this study, we propose that greater conceptual clarity might be achieved by exchanging the terms 'primary' and 'secondary' for 'natural' and 'supernatural', respectively. Rothbaum et al. (1982) meant for the original terms to indicate that, in instances of perceived secondary control, a higher force rather than the individual takes the controlling action. In this study, the illusion of control is defined as a theory-driven belief in an effective personal action, be it a strategy or ritual. In the case of a ritual, the theory (belief structure) driving the action concerns supernatural agents and their powers. In the case of a strategy, the underlying theory pertains to natural phenomena. It, therefore, seems more appropriate to distinguish between variants of the illusion of control based on the belief structures that potentially inform them.

From a psychometric perspective, these findings are generally consistent with the broad two-factor structure observed by Wood and Clapham (2005) in the development of *Drake Beliefs About Chance Inventory*. One of the observed factors expresses beliefs that winning odds can be improved through supernatural means (illusory secondary control), whereas the other expresses beliefs that winning odds can be improved through natural means, including strategies based on the gambler's fallacy (illusory primary control). Other similar distinctions are observed in the *Gambler's Beliefs Questionnaire* (Steenbergh et al., 2002) that captures a distinction between the same illusion of primary control factor and a 'Luck/Perseverance' factor. In combining statements about the value of persistence with statements about luck, the latter factor captures the 'cyclical luck' component of the illusion of secondary control – the belief that one should persevere in waiting for a period of good luck. On the other hand, there are items in the often cited *Gambling Related Cognitions Scale* (Raylu & Oei, 2004) that appear ambiguous in that it is unclear how the beliefs they express might have emerged from the gambler's fallacy or supernatural beliefs: "Relating my losses to bad luck and bad circumstances makes me continue gambling", "Relating my losses to probability makes me continue gambling", and "Remembering how much money I won last time makes me continue gambling".

Clinical and policy implications

Many modern treatment programs and community education initiatives for problem gambling are aimed at correcting erroneous gambling-related beliefs. Our work can be seen as evidence about internal theories of the world that are a cause of such beliefs. The evidence can be used to develop more coherent typologies of beliefs for discussion with patients. At the same time, the evidence suggests that explaining why various types of beliefs are erroneous is only one component of therapy and education. The other must address the internal-theory-based causes of the beliefs: the gambler's fallacy and beliefs in the supernatural. As general theories of the world which may have an evolutionary history, these causes might not be reversible through therapy. Instead, therapists might need to explain to patients that humans have two ingrained broader belief structures or information processing tendencies that make them prone to developing erroneous beliefs in gambling settings, which are to be avoided for this reason.

As a working example, our findings have implications for an influential belief-correction procedure developed in the last two decades by Ladouceur and colleagues (e.g., Toneatto & Ladouceur, 2003; Ladouceur, Sylvain, Boutin & Doucet, 2002). A clinically trialled version of this procedure (Ladouceur et al., 2001) had four objectives, the first two of which are quoted below:

> a) understanding the concept of randomness: the therapist explained the concept of randomness, that each "throw of the dice" is independent, that no strategies exist to control the outcome, that there is a negative expectation of gain, and that it is impossible to control the game; b) understanding the erroneous beliefs held by gamblers: this component mainly addressed the difficulty of applying the principle of independence of random events: the therapist explained how an illusion of control contributes to the maintenance of gambling habits, and then corrected these erroneous beliefs... (pp. 776-7)

The procedure's emphasis on explaining the 'independence' of random events is consistent with our conceptual framework. Many erroneous beliefs stem from the gambler's fallacy, so explanation of the principle of independence should alert the patient to the error of many of their beliefs.

Where Ladouceur's approach is inconsistent with our results is in its presentation of the illusion of control as *another* underlying cause of erroneous beliefs. In our framework, this underlying causal role is played by the gambler's fallacy, while the illusion of control is a descriptive term for expressed erroneous beliefs. In other words, our results suggest that a more coherent approach would involve explaining that erroneous beliefs are illusions driven by the general gambler's fallacy. Treatment could, further, involve outlining various explanations for why the gambler's fallacy is so widespread. Tversky and Kahneman's (1974) notion of a representativeness bias is one explanation and it was mentioned earlier in this paper. Another explanation, put forward by Estes (1964), describes the gambler's fallacy as a branch of the rational belief that many real-world outcomes follow a law of sampling without replacement. Given the way weather systems work, for instance, it is rational to assume that a sunny period draws nearer with each day of rain (see Hahn and Warren 2009 for a third theory). The next step would be to explain that gambling environments are dangerous and need to be avoided because they take advantage of the human proneness to the gambler's fallacy and ensuing erroneous beliefs.

According to our results, Ladouceur and colleagues' approach could also benefit from greater emphasis on common gambling-related beliefs about luck, rituals and other supernatural phenomena. Since, according to Atran and Norenzayan (2004), these beliefs share evolutionary and conceptual roots with religious beliefs, explaining why they are erroneous could present difficulties. For example, explaining why a certain ritual is ineffective could involve challenging the existence of God. Once the erroneous nature of some of the patient's specific supernatural gambling beliefs is established, the therapist can explain that these beliefs are the product of a more ingrained belief structure that is, like the gambler's fallacy, likely to be evolved. Atran and Norenzayan (2004) present a comprehensive evolutionary account of how beliefs about supernatural agents, their power and their responsiveness to rituals came to be related.

In sum, our findings help distinguish between gambling-related beliefs and their causes, and between two causes. This should allow therapists to work from a more coherent typology of beliefs and should encourage them to warn patients about the potential immutability of the causes – an immutability that makes gambling environments highly dangerous.

Limitations

A clear limitation of the study is that our hypotheses regarding the hierarchical structure of gambling-related beliefs could feasibly only be tested through CFA, which is customarily performed on scale scores. Therefore, our model accounted for variance in averaged rather than raw agreement scores. In addition, the averaged scores (expressing the six belief sub-categories) were calculated based on purely theoretical grounds rather than exploratory statistical ones. However, with a cross-loading 'cyclical nature of luck' sub-category, the belief sub-categories were not detectable through exploratory factor analysis.

Apart from the cross-loading of the 'cyclical luck' sub-category, a source of blurred factor boundaries would have been the high correlation between the latent primary and secondary illusory control constructs. A potential source of this correlation is the fact that both primary (natural) systems of play and secondary (supernatural) rituals are sometimes acquired through a common mechanism – reinforcement learning (e.g., Skinner, 1948). The removal of weak items would have ensured that some beliefs held only by experienced participants as a result of extensive reinforcement learning were not analysed, however.

Conclusion

We attempted to reconcile three frequently cited concepts in factor-analytic research on erroneous gambling-related beliefs. These are the illusion of control, the distinction between illusions of primary and secondary control, and the gambler's fallacy. Groupings for gambling-beliefs survey statements were suggested based on the proposal that the illusion of control, a set of beliefs about effective gambling action patterns, is caused by general belief structures such as the gambler's fallacy, in interaction with situational factors. The gambler's fallacy gives rise to the illusion of primary (natural) control while a general set of beliefs about supernatural agents gives rise to the illusion of secondary (supernatural) control. Seventy survey statements were then categorised in line with the suggested groupings, and CFA was used to demonstrate that category intercorrelations expressed higher-order natural and supernatural illusion-of-control constructs. The findings have implications for research on the illusion of control and for how erroneous gambling-related beliefs are discussed in treatment settings. More broadly, the findings provide preliminary evidence for a perspective that gambling-related beliefs are, at least in part, a function of broader belief systems that people bring to the session and which come to act as information processing filters.

Appendices for Chapter 5

Appendix 5A

Participant instructions

Below are 100 statements about gambling. Read each statement carefully and indicate the degree to which you agree or disagree with it. Unless a statement explicitly refers to a particular type of gambling (e.g., dice, lotteries) consider it a statement about poker machine gambling. Don't spend too long thinking about any particular statement. Just go with your initial reaction. Spend approximately 20 seconds on each statement.

Scale

Strongly disagree (-3), Disagree (-2), Moderately disagree (-1), Neither agree nor disagree (0), Moderately agree (1), Agree (2), Strongly agree (3)

Sources

- Drake Beliefs About Chance Inventory (DBC; Wood & Clapham, 2005)
- Gamblers' Beliefs Questionnaire (GBQ; Steenbergh, Meyers, May & Whelan, 2002)
- The Predictive Control Scale of the Gambling Related Cognitions Scale (GRCS; Raylu & Oei, 2004)
- The Informational Biases Scale (IBS; Jefferson & Nicki, 2003)
- Thoughts and Beliefs About Gambling questionnaire devised by (TBAG; Joukhador, Maccallum & Blaszczynski, 2003)
- Questionnaire developed by Moore and Ohtsuka (1998)
- Weinstein Event Characteristics (W; included in Moore and Ohtsuka, 1999)
- Primary and Secondary Control Beliefs Scale (PSCB; Williams, 2007, unpublished Honours thesis)
- Belief in Good Luck Scale (BIGL; Darke & Freedman, 1997)

Terminology

In South Australia, where the survey was administered, slot machines are typically referred to as "poker" machines.

Items

1. The longer I've been losing, the more likely I am to win. (DBC)
2. I should keep the same bet even when it hasn't come up lately because it is bound to win. (GBQ)
3. If I am gambling and losing, I should continue because I don't want to miss a win. (GBQ)
4. Even though I may be losing with my gambling strategy or plan, I must maintain that strategy or plan because I know it will eventually come through for me. (GBQ)
5. I have some control over predicting my gambling wins. (GRCS)
6. If I keep changing my responses, I have less chances of winning than if I keep the same response every time. (GRCS)
7. Losses when gambling are bound to be followed by a series of wins. (GRCS)
8. If I'm experiencing a losing streak the thought that a win has to be coming soon keeps me gambling. (IBS)
9. Sometimes I feel that I can keep winning because I have learned to predict the next random, new thing the machine is going to do. (Newly-written, Ayton and Fischer 2004)
10. Winning in poker machine gambling is a matter of knowing how random patterns work. Each time, the machine is bound to do something different to what it did in the previous round. (Newly-written, Ayton and Fischer 2004)
11. I will be more successful if I have a system for playing poker machines. (DBC)
12. A good poker machine, roulette or dice gambler is like a sportsperson who knows winning plays and when to use them. (DBC)
13. There are secrets to successful poker machine, roulette and dice gambling that can be learned. (DBC)
14. Show me a [poker machine] gambler with a well-planned system and I'll show you a winner. (DBC)
15. The more familiar I am with poker machine gambling, the more likely I am to win. (DBC)
16. One should pay attention to lottery numbers that often win. (DBC)
17. A game of chance is a contest of wills between the game and the player. (DBC)
18. Playing poker machines is a form of competition between the player and the machine. (DBC)
19. My choices or actions affect the game on which I am betting. (GBQ)

20. My gambling wins are evidence that I have skill and knowledge related to gambling. (GBQ)
21. My knowledge and skill in gambling contribute to the likelihood that I will make money. (GBQ)
22. I have more skills and knowledge related to gambling than most people who gamble. (GBQ)
23. I am pretty accurate at predicting when a win will occur. (GBQ)
24. I should keep track of previous winning bets so that I can figure out how I should bet in the future. (GBQ)
25. When I am gambling, “near misses” or times when I almost win remind me that if I keep playing I will win. (GBQ)
26. I think of poker machine gambling as a challenge. (GBQ)
27. When I have a win once, I will definitely win again. (GRCS)
28. A series of losses will provide me with a learning experience that will help me win later. (GRCS)
29. I believe I can beat the system. (TBAG)
30. If I lose it’s because something unforseen has happened. (TBAG)
31. I know I can win if I follow my strategies. (TBAG)
32. Identifying a pattern helps me predict a winner. (TBAG)
33. The chances of winning improve after a near win. (TBAG)
34. When I've lost it's because I've made a hasty decision or didn't concentrate. (TBAG)
35. The way in which I press the buttons on the poker machine can influence the outcome. (PSCB)
36. Winning on poker machines is all about knowing the right time to get on the machine. (PSCB)
37. There is a definite type of person who has big wins at gambling. (W)
38. To be successful in poker machine gambling it is important to know how to maintain a winning streak when one comes around. (Newly-written based on Ocean and Smith, 1993)
39. To be successful in poker machine gambling it is important to know how to change the flow of the game when facing a losing streak. (Newly-written based on Ocean and Smith, 1993)

40. The machines pay out more at different times of day. (Newly-written based on Livingstone, Wooley and Borrell, 2006)
41. You can win more money overall if you know how to make good use of free spins. (Newly-written Livingstone, Wooley and Borrell, 2006)
42. Where I get money to gamble doesn't matter because I will win and pay it back. (GBQ)
43. In the long run, I will win more money than I will lose gambling. (GBQ)
44. If I continue to gamble, it will eventually pay off and I will make money (GBQ)
45. If I lose money gambling, I should try to win it back. (GBQ)
46. Those who don't gamble much don't understand that gambling success requires dedication and a willingness to invest some money. (GBQ)
47. Wins are more likely to occur on a hot machine (i.e. a machine that has just paid out). (DBC)
48. It is good advice to stay with the same pair of dice on a winning streak. (DBC)
49. There are times that I feel lucky and thus gamble those times only. (GRCS)
50. Luck works in cycles and is, therefore, predictable to some extent. (Newly-written based on Keren and Wagenaar, 1985)
51. A series of losses is a sign that good luck is about to set in. (Newly-written based on Duong and Ohtsuka, 2000)
52. You should make at least one bet every day. Otherwise, you might be walking around lucky and not even know. (Newly-written based on Aasved, 2002)
53. It is important to bet big when you feel that you've come across a lucky way of playing the machine. (Newly-written based on King, 1990)
54. Luck sometimes hides all the wins behind a certain response pattern, so it's always worth sticking with a response pattern that has just produced a win to check whether you've stumbled upon a lucky way of playing. (Newly-written based on King, 1990)
55. I believe that fate is against me when I lose. (DBC)
56. There is useful information in my daily horoscope. (DBC)
57. Some gamblers are just born lucky. (DBC)
58. Following lucky signs can help me win. (TBAG)
59. I have the psychic ability to predict a winner [in poker machine gambling]. (TBAG)
60. Bad vibes from people around me cause me to lose. (TBAG)

61. I make the right choice because I'm generally lucky. (TBAG)
62. It's possible for the good or bad luck of other players at the gambling venue to rub off on me. (Newly-written based on Duong and Ohtsuka, 2000)
63. There may be magic in certain numbers [or actions]. (DBC)
64. When I need a little luck I wear lucky clothes or jewellery. (DBC)
65. I can improve my chances of winning by performing special rituals. (DBC)
66. I like to carry a lucky coin, charm or token when I'm doing something important. (DBC)
67. I have a "lucky" technique that I use when I gamble. (GBQ)
68. There are certain things I do when I am betting (for example, tapping a certain. number of times, holding a lucky coin in my hand, crossing my fingers, etc.) which increase the chances that I will win. (GBQ)
69. Sometimes I think I might have the power to 'will' my desired outcomes to come up [during poker machine play]. (Moore & Ohtsuka, 1998)
70. You never know what might happen if you don't perform certain rituals while gambling. (Newly-written based on Rudski and Edwards, 2007)

--- Removed prior to model fitting:

71. I do not consider myself to be a superstitious person. (DBC)
72. Winning in poker machine gambling is based entirely on chance. (TBAG)
73. The outcome of one poker machine event has no effect on the outcome of the next. (TBAG)
74. It's a mistake to base any decisions on how lucky you feel. (BIGL)
75. Luck is nothing more than random chance. (BIGL)
76. The likelihood of winning a large amount of money in poker machine gambling is so small, it's not worth bothering. (Moore & Ohtsuka, 1998)
77. I do not expect to win at gambling. (Moore & Ohtsuka, 1998)
78. There is no way of predicting when a win will occur in poker machine gambling. (Newly-written)
79. There is nothing the player can do to influence the outcome of poker machine gambling. (Newly-written)
80. In poker machine gambling there is no place for any kind of special knowledge. (Newly-written)

81. No matter what system of play you adopt in poker machine gambling, your chances of winning are no different to anyone else’s. (Newly-written)
82. Near-misses in poker machine gambling are not a sign that a win is close by. (Newly-written)
83. It is true that any run of losses eventually comes to an end, but this does not mean that I can predict when to raise my bet amounts ahead of a win. (Newly-written based on Delfabbro, 2004)
84. Luck does not follow a pattern. (Newly-written)
85. A gambler can’t be lucky or unlucky by nature. (Newly-written)
86. Lucky items or charms can’t help a person when playing poker machines. (Newly-written)
87. Once you have lost money on poker machine gambling, there is no point playing on to win it back. (Newly-written)
88. I have a special system for picking lottery numbers. (DBC)
89. If a coin is tossed and comes up heads ten times in a row, the next toss is more likely to be tails. (DBC)
90. When I take a test (or took them in the past) I use a lucky pen or pencil. (DBC)
91. Gambling is more than just luck. (GBQ)
92. If I win on a certain machine, I am more likely to use that machine again at a later date. (IBS)
93. After a long string of wins on a machine, the chances of losing become greater. (IBS)
94. A run of losses must come to an end sooner rather than later. (TBAG)
95. There is a definite type of person who has big losses at gambling. (W)
96. A person's chances of winning are better if they gamble on a machine that has not paid out in a long time. (PSCB)
97. I try to bet on the maximum number of lines because I don’t want to miss out on a big win on a line I didn't gamble. (Newly-written based on Livingstone, Wooley and Borrell, 2006)
98. Since poker machines are a game of chance and chance distributes wins evenly across different possible responses, the only way to win is to keep ‘changing up’ your play pattern. (Newly-written based on Keren and Wagenaar, 1985)
99. Luck works in a different way to chance. (Newly-written based on Wagenaar and Keren, 1988)

100. It can't hurt to perform little rituals during gambling – just in case. (Newly-written based on Rudski and Edwards, 2007

CHAPTER 6: Conclusion

The opening chapter reviewed research on factors that might influence the illusion of control and proposed an explanation for the psychological processes that give rise to the illusion and cause it to increase with increasing choice, need for the outcome, and so on. The chapter concluded that research needed to be conducted to address a number of gaps in findings relating to factors that influence the illusion, success-frequency and success-slope in particular. The chapter also called for research aimed at testing the proposed psychological-process explanation. These suggestions for further research became the basis for four research questions addressed in this thesis. The first two relate to factors influencing the illusion of control:

1. Is success-frequency among the factors that influence the illusion of control?
2. Is success-slope an influencing factor, with the illusion of control being highest following a descending success-slope (i.e., when participants experience most wins early in the playing session)?

The other two research questions relate to the proposed explanation for the psychological processes underlying the illusion:

3. Do people in gambling tasks engage in problem-solving in pursuit of a sizeable win, with this then giving rise to the illusion of control – some degree of belief in various playing strategies?
4. Does the illusion of control have two discernable variants, reflecting the gambler's fallacy and beliefs about supernatural forces such as luck?

This chapter summarises the findings of this the thesis in relation to each of the four research questions identified above. It also presents additional relevant findings that could not be included in the papers because of length restrictions. Further research questions arising from the main findings and supplementary findings are also discussed. Section 1 is concerned with factors influencing the illusion of control. More specifically, the section presents a summary of Paper 1, which investigated the success-frequency effect. A summary of Paper 2, which investigated the success-slope effect, is also provided, along with additional findings and future research questions relevant to both investigations. Section 2 describes findings, additional analyses and future research questions relating to the present psychological-process explanation for the illusion of control. The experiment in Paper 2 made possible an investigation of whether people engage in problem-solving in gambling tasks. More specifically, the experiment made possible an investigation of whether participants in the ascending success-slope condition (i.e., those experiencing a concentration of wins at the end of the playing session) perceived themselves to have learned the correct playing strategy through trial-and-error. Paper 3 was concerned with the other research question relating to the explanation: the question regarding the two variants of the illusion of control and the abstract beliefs underpinning them.

Section 3 of this chapter is concerned with the methodological implications of this work, whereas Section 4 focuses on practical applications, which largely have to do with the clinical treatment of problem gambling.

1. Influences on the illusion of control

1.2. Success-frequency

In Paper 1, ratings of inferred control on the traditional single-scale measure of perceived control increased with success-frequency, but ratings of illusory primary and secondary control on the newly-developed measure did not. The paper's implicit interpretation of the finding was that the two measures assessed different phenomena. According to this interpretation, the traditional measure assessed the number of remembered successes, whereas the new measure assessed the illusion of control, the strength of the inferred causal relationship between personal actions and successes. The paper, in effect, concluded that success-frequency does not influence the illusion of control. This appears to run contrary to the psychological-process explanation of the illusion presented in Chapter 1. According to the explanation, a high success-frequency should suggest effective problem-solving and, thus, increase the illusion of control. However, problem-solving involves not simply repeating previously successful actions, but assessing whether an action has brought one closer to the end goal (i.e., 'hill-climbing'; Anderson, 1993). In gambling contexts, the end goal is a substantial win, so high success-frequency might only have an effect to the extent that it results in larger wins (i.e., greater proximity to the end goal). In this study, the final win-amount after 100 trials was kept constant across success-frequency conditions, potentially explaining the lack of effect.

The paper's finding has three alternative interpretations, not discussed in the original paper due to length restrictions. One possibility is that success-frequency does influence the illusion of control independently of win-amount but the new measure did not show the effect because it was invalid or not reliable. A second possibility is that the effect exists independently of the effect of win-amount but neither measure was suitable for gauging it. Scores on the traditional measure might have varied in line with success-frequency only because they reflected remembered success-frequency rather than perceived control. A third possibility is that the success-frequency effect exists independently of win-amount but cannot be gauged using the soccer task. The task contains many choice alternatives (bet options, player profiles and kick directions), and the illusion of control is known to increase with the number of such alternatives (see Chapter 1). It is, therefore, possible that perceived control levels in the task were at ceiling-level and not subject to variation across any manipulated independent variable including success-frequency.

Appendix 6A describes a partial test of some of these interpretations based on the available data. The test involved examining the extent to which variations in the amount won at the end of the session predicted ratings of perceived control. It was found that the illusions of primary and secondary control as gauged by the new measure increased with win-amount, whereas ratings on the traditional measure remained constant. These results rule out the possibility of the illusion of control being at ceiling, since the illusion, as gauged by the new measure, did vary in line with an independent variable – win-amount. The results also run counter to the interpretation that the new measure was too unreliable to show systematic variability. Instead, the results suggest that the traditional measure and the new measure behave differently depending on what variable is manipulated. The traditional measure appears more sensitive to success-frequency manipulations, consistently with Jenkins and Ward's (1965) proposal that it reflects remembered success-frequency rather than perceived control.

Overall, then, the findings in Appendix 6A leave open two possibilities. One is that the illusion of control is influenced not by success-frequency per se, but by the size of winnings, which can sometimes be related to success-frequency. This proposal might appear counterintuitive, since high success-frequency is a typical hallmark of solving a problem or at least being close to the desired goal state. However, as Anderson (1993) notes, for the researcher, assessing what it means to be ‘close’ to a goal state in different problem-solving domains is not trivial. In gambling contexts, where the end goal is a win of a large size, it makes some sense that closeness to the goal state is conceived of in terms of the size of wins rather than their frequency.

An alternative interpretation is that success-frequency influences the illusion of control independently of win-amount but has a weaker effect than win-amount. The new measure, with its reliance on factor analysis, might be too unreliable to detect the success-frequency effect with this sample-size.

To test these two interpretations against each other, a future study could manipulate success-frequency and win-amount in a 2 x 2 design (low/high success-frequency x low/high win-amount). The soccer task could be used, with participants experiencing a success-frequency of 1/16 or 1/2. As is indicated in Figure 2.1, the soccer task can be programmed to show each goal and miss (i.e., each win and loss) as being ‘close’ or ‘far’, with ‘far’ goals involving wrong-footing of the goalkeeper. Given this feature, win-amount could be manipulated by informing participants that a goal that wrong-foots the goalkeeper results in a doubling of the winnings for that trial, and participants in the high win-amount condition could be pre-programmed to experience more wrong-footing goals than participants in the low win-amount condition. The new measure could be used as the measure of perceived control. With larger cell counts (e.g., 40 participants in each group), any existing independent effect of success-frequency should come to be reflected in a main effect of success-frequency. If the success-frequency effect is, instead, an effect of win-amount, the results should point to a main effect of win-amount without a main effect of success-frequency.

1.3. Success-slope

In Paper 2, inferred (primary) control was found to be highest following an ascending success-slope and lowest following a descending one. This result could reflect raised perceived control in the ‘ascending’ condition due to perceived learning. Alternatively, it could reflect lowered perceived control in the 'descending' condition due to the absence of perceived learning. It is also possible that both of these effects were present. In either case, the result contradicts what has, to-date, been considered the standard finding in relation to success-slope effects.

Records of behaviour on each trial in the success-slope study can be used to determine which of these two interpretations is correct. More specifically, as suggested in the Discussion section of Paper 2, behaviour across success-slope conditions could be examined for signs of participants settling on fewer player-profile and kick-direction options over time, as though settling on a learned strategy for playing. Under the hypothesis that experiencing an ascending success-slope creates the impression of learning, decreasing behavioural variability over time should be observed in the 'ascending' condition only. Under the alternative hypothesis that a perception of learning is created by all but a descending success-slope, the 'descending' condition should be unique in not exhibiting decreasing behavioural variability. If both of the interpretations are valid, all but the 'descending' condition should give rise to decreasing behavioural variability with the pattern being more pronounced in the 'ascending' condition. Appendix 6B presents analyses in which the number of player profile changes in the first 24 trials was compared to the number of such changes in the last 24 trials. On the whole, the findings favoured the first interpretation in showing that the 'ascending' condition was the only one in which participants decreased their player-profile-change propensity over time. The same was the case for variability in kick-direction choices, as quantified by an entropy measure. Thus, participants in the 'ascending' condition showed a tendency to settle on fewer player-profile and kick-direction options over time, as though they were settling on a 'learned' strategy for playing.

The results of Paper 2 also showed that estimates of remembered success-frequency did not vary across success slopes and showed a number of trends consistent with those observed in the memory literature. For example, the fact that higher goal frequency estimates were observed when the question referred to 'misses' rather than 'goals' was consistent with a 'spacing effect', which refers to better memory for items more widely dispersed across time (e.g., Glenberg, Bradley, Kraus & Renzaglia, 1983). In addition, the overestimation of the objective success-frequency (1/6) in the ‘descending’ and ‘flat’ conditions might have been due to the combination of the ‘primacy’ and ‘spacing’ effects with an ‘over-under effect’, in which low event frequencies are systematically overestimated (e.g., Lichtenstein et al., 1978). These analogies with the memory literature suggest that past studies of the effects of success-slope might have been concerned with the factor’s effect on memory for events (in this case, wins) rather than inferred control. However, all of these proposals regarding evident memory effects require formal testing.

Existing data, albeit not from the same study, can also be used to test one of these assertions regarding memory processes underlying success-frequency estimates. The assertion is that overestimation in the ‘descending’ and ‘flat’ conditions was a potential instance of an ‘over-under effect’, which refers to the consistent overestimation of lower frequencies and the underestimation of higher ones. It has been suggested that the effect is driven by background beliefs about the domain, in that people have beliefs about what the event frequency in a particular domain is and anchor their estimates to that value. For example, if they believe that slot machines should deliver a win once in *x* rounds but experience a higher win frequency, they adjust success-frequency estimates in the direction of *x* (i.e., downwards; Lichtenstein et al., 1978).

In this case, it was speculated that 1/6, the objective success-frequency, was a low event frequency subject to overestimation across all conditions. Without this overestimation, participants’ estimates in the ‘descending’ and ‘flat’ conditions would have been accurate or nearly so, due to the ‘primacy’ and ‘spacing’ effects present in those conditions. Meanwhile, estimates in the ‘U-shaped’ and ‘ascending’ conditions would have been underestimates. Presumably, as discussed above, the systematic upwards-adjustment occurred due to certain regularities in participants’ prior beliefs about the frequency of wins in gambling and soccer. If this interpretation is valid, evidence should suggest that, in the context of the soccer-themed gambling task, 1/6 is indeed a success-frequency level subject to overestimation, unlike some higher frequencies.

As is shown in Appendix 6C, data from the study on success-frequency (Paper 1) provide preliminary evidence in support of this proposition. The study featured five success-frequency conditions, and the data of interest concerned prospective and retrospective success-frequency estimates across conditions. These estimates were obtained alongside ratings of perceived control but have not been discussed up to this point because they were not relevant to the issues considered in Chapter 1. The pattern of estimates across conditions (see Appendix 6C) constitutes evidence for the 'over-under effect' in that it suggests that (a) participants systematically overestimated lower frequencies while accurately estimating higher ones, and (b) 1/6 was among the overestimated frequencies. These conclusions are only preliminary, however, in that they are advanced based on somewhat suboptimal statistical tests (see Appendix 6C for further discussion).

Another of the paper's proposals regarding the memory processes underlying success-frequency estimates was that the 'recency effect' (better memory for events late in the sequence) disappeared in the 'ascending' condition due to the time that elapsed between the end of the task and the presentation of success-frequency questions. The proposal remains to be tested, and the test would involve additionally manipulating the length of time interval before the presentation of success-frequency questions. When the time interval is close to zero, estimates in the 'ascending' condition should resemble those in the 'descending' condition. That is, at a 1/6 success-frequency, assuming the operation of an 'over-under effect', estimates in both conditions should involve overestimation of the objective success-frequency.

1.4. Number of action alternatives

As outlined in Chapter 1, much of the literature on the illusion of control has been concerned with the effects of providing additional action alternatives – additional opportunities for choice, physical involvement, stimulus familiarity, thinking time, practice, competition, and foreknowledge, or extra need for the outcome. While the studies in this thesis did not follow up on these findings, the featured experimental methodology can be applied in investigating the effects of the listed factors.

Existing experiments on the effects of these factors have left open a number of questions. Apart from the effects of choice and need for the outcome, all of the effects have been observed in so few studies that they are in need of replication. The effects of stimulus familiarity, foreknowledge and practice are additionally unclear, in that the former two effects could represent effects of suspicion while the latter could represent a demand effect (see Chapter 1). Furthermore, for all factors, the only evidence of their effect on the illusion of secondary control comes from studies of lotteries, where the factors have been found to be influential despite the absence of opportunity for any kind of physical action. The factors' effects on the illusion of secondary control are yet to be investigated in games of chance other than lotteries.

As was suggested in the Discussion section of Paper 2, manipulating choice and stimulus familiarity in the soccer-themed experimental task would involve removing task features. For example, choice could be manipulated by creating a version of the task without kick-direction choices for the group with less choice. Similarly, stimulus familiarity could be manipulated by making the soccer players featured in the game unknown or less recognisable in the version of the task presented to the 'low familiarity' group. As in any other experimental task, thinking time, degree of opportunity for practice, and opportunity for competition can also be manipulated over the course of the playing session.

A particular advantage of the soccer-themed task is that it allows stimulus familiarity to be manipulated without creating suspicion. Past research on stimulus familiarity has been inconclusive as to whether 'low familiarity' groups perceived less control because of fewer available strategies or because of suspicion that the game's strange stimuli were a sign that the game was rigged in some way. For example, in a card-drawing task in one experiment (Bouts & Van Avermaet, 1992), participants in the 'low familiarity' group might have been suspicious of the strangely-shaped cards and Egyptian symbols used in that group. In the soccer-themed task and in any analogous partially novel gambling task, participants would have fewer preconceptions about the task stimuli. Another advantage of the featured methodology is that it enables the factors' effects on the illusion of secondary control to be examined in a task other than a lottery.

2. The psychological processes underlying the illusion

Papers 2 and 3 tested the main hypotheses of a proposed explanation for the psychological processes underlying the illusion of control. The first of these hypotheses, tested in Paper 2, is that the illusion of control is a by-product of attempted problem-solving in gambling tasks. The paper's main findings and the supplementary findings discussed above suggest that people in gambling tasks do have a problem-solving orientation in that they consider an ascending success-rate to be indicative of them having learned the ‘correct’ way of playing.

Paper 3 tested the explanation’s hypothesis that the problem-solving solutions people arrive at in gambling settings are of two types – solutions based on beliefs about supernatural forces, and solutions based on other beliefs, including the gambler’s fallacy. In the paper, the model fitted using CFA displayed good fit to the scale covariance matrix, suggesting that, to the extent that it was captured by scores on the six created scales, the illusion of control contains two variants, reflecting the gambler’s fallacy and beliefs about the supernatural. As pointed out in the paper’s Discussion, the chief limitation of the study was that the CFA model’s good fit might have been due to the manner in which items were grouped into scales. Indeed, as described in the paper’s Introduction, the groupings were informed by the hypothesis being tested.

The hypothesis examined in the study can, however, be tested on the raw data set rather than a set of arbitrary scale scores. Appendix 6D presents an exploratory factor analysis (EFA) of the survey items in order to determine how many latent item groupings best describe them (e.g., Costello & Osborne, 2005; Floyd & Widaman, 1995). In an EFA, the study’s hypothesis would be that the items are best-described by two latent groupings, reflecting the gambler’s fallacy and supernatural beliefs, respectively. The ‘cyclical luck’ items were excluded from the EFA because EFA is difficult to apply when items load on multiple factors, as the ‘cyclical luck’ items did in the main study (MacCallum et al., 1999). As the appendix shows, the hypothesised two-factor structure was obtained.

The conducted EFA is useful not only as an alternative test of the thesis’ arguments regarding the belief structures influencing the illusion of control, but also as a mechanism for identifying further weak items for potential exclusion in future surveys of erroneous gambling-related beliefs. Candidates for exclusion are items with weak factor loadings (e.g., item 22 in Appendix 6D) and items with similar loadings on both factors (e.g., items 14 and 61 in Appendix 6D).

The thesis’ arguments regarding the psychological processes driving the illusion of control leave open at least one question about the structure of the illusion.

The question relates to the distinction between the gambler's fallacy and beliefs about non-supernatural phenomena. Problem-solving involves an interaction between background beliefs and situational factors, such as the number of available action alternatives. Beliefs can cause certain situational factors to be noticed and situational factors can, upon being noticed, cause certain beliefs to be activated (Murphy & Medin, 1985). It is, in turn, feasible that the gambler's fallacy and beliefs about other physical entities do not draw attention to, and are not activated by, the same situational factors. The question is, however, whether non-supernatural beliefs other than the gambler's fallacy are applied often enough in gambling contexts to warrant the associated problem-solving being labelled a separate variant of the illusion of control. To answer this question, it is necessary to examine whether any factors found to have an influencing effect in the present soccer task have the same effect in a task where gambler's-fallacy-based strategies are the only possible form of primary control. Roulette is such a task, for example, since it allows for the gambler's-fallacy-based selection of numbers and colours that have not won in some time but does not feature themes (e.g., soccer) that could form the basis for other strategies. If success-frequency and success-slope effects in the context of this task show a different pattern to those in the soccer task, there would be reason to distinguish between the illusion of gambler's-fallacy-based control and other types of the illusion of primary control.

3. Methodology for researching influencing factors

As discussed in Chapter 1, assuming the illusion of control to be a problem-solving phenomenon with gambler's-fallacy-based and supernatural variants has a number of implications for the methodology used in examining influences on the illusion. Following the successful testing of these base assumptions, studies on factors influencing the illusion should consider including the following features. First, the experimental task should be recognisable as a gambling task. This should automatically facilitate problem-solving and encourage application of the gambler's fallacy, the driving force behind the illusion of primary control. The experiments in this thesis used a task that was only partially recognisable, and such tasks have the advantage of being representative of a variety of gambling tasks rather than one specific task.

The second methodological guideline for future experimental work is that the illusions of primary and secondary control should be measured separately, since they may reflect strategising based on different belief structures (gambler's fallacy vs. beliefs about supernatural forces). In light of confirming evidence for the assumption that the illusion of control is a problem-solving phenomenon (see Section 2), it is also desirable for the measure to consist of a listing of potential problem-solving solutions (i.e., methods of obtaining wins) that participants evaluate as being representative or not representative of the solutions they might be considering at that moment. The measure used in Papers 1 and 2 implements these guidelines but is a work-in-progress in terms of the constituent listed problem-solutions and their wording.

4. Applications

In Australia, national surveys have concluded that of the 80 to 92% of adults who have gambled at some time in their lives (Australian Productivity Commission, 1999, 2010; Griffiths & Delfabbro, 2001), approximately 2% are 'problem gamblers'. Problem gamblers have a genuine desire to stop gambling but continue to gamble regularly, experiencing heavy financial losses, chasing those losses, often with borrowed money, and, in general, dedicating to gambling more time and money than intended (Blaszczynski & Nower, 2002). Of all gambling forms, slot-machine play is most strongly associated with problem gambling, in that approximately 15% of people who gamble on machines weekly or more often report symptoms indicative of problem gambling (Australian Productivity Commission, 1999, 2010). Other developed countries report similar statistics (e.g., Bakken et al., 2009; Ladouceur, 1996; Shaffer, Hall & Vander Bilt, 1999; Wardle et al., 2007).

Numerous explanations of problem gambling have proposed that erroneous gambling-related beliefs play a principal role in the development of problem gambling (Walker, 1992b; Ladouceur et al., 2002), or are at least sufficient causes (Blaszczynski & Nower, 2002). This thesis, in turn, identifies abstract belief structures that give rise to considered problem-solutions in gambling settings, and, with that, most erroneous gambling related beliefs. Essentially, the thesis provides a theoretically-grounded typology of these beliefs, tracing each belief back to more abstract beliefs about supernatural agents, the gambler's fallacy, other beliefs about the physical world (e.g., beliefs about how slot machines are programmed), or some combination of these. Not only is this typology theoretically-motivated, it also specifies fewer belief categories than existing typologies (e.g., Toneatto et al., 1997). Both of these features make the typology highly suitable as the basis for classifying and correcting a person's erroneous beliefs in treatment settings.

At the same time, however, the present findings regarding the abstract beliefs underpinning the illusion of control raise questions about the feasibility of 'correcting' beliefs that stem from such abstract belief structures. Given their evolutionary history, the abstract beliefs might not be reversible, implying that they might continue to generate erroneous problem solutions in gambling settings. Even if it is possible to reverse or weaken the abstract belief structures, the therapist is likely to face some difficulties in doing so, especially with respect to abstract beliefs about supernatural forces such as luck and fate. Many therapies have focused on correcting the gambler's fallacy by explaining the way in which commercial gambling environments are built to preserve the independence of outcomes from trial to trial (e.g., Ladouceur et al., 2002). However, approaches to countering beliefs about supernatural agents have not been investigated in relation to gambling, most likely because these beliefs are often related to personally and culturally significant religious belief structures.

5. Summary

Future investigations of the relationship between success-frequency and the illusion of control should focus on determining whether higher success-frequency augments the illusion only insofar as it leads to a higher accumulated win-amount. Investigations of success-slope should focus on ascertaining that estimates of remembered success-frequency after various success-slopes show trends similar to those observed in research on human memory. Further evidence of this would add weight to the second paper's conclusion that estimates of remembered success-frequency are not suitable proxies for ratings of perceived control in experiments concerned with success-slope effects.

Another set of open research questions pertains to the effects on the illusion of control of stimulus familiarity, thinking time, opportunity for practice, opportunity for competition, and foreknowledge. Each of these factors has been found to affect the illusion in only one or two studies, so replications are in order. These studies could be conducted using the same experimental task and perceived-control measure as the success-frequency and success-slope studies in this thesis. New tasks and measures could also be developed, as long as the experimental task is at least partially recognisable as a gambling game and the measure gauges the illusions of primary and secondary control separately. It is also advisable that the measure contain a listing of task strategies participants are likely to consider over the course of the gambling session. The effects of stimulus familiarity are best investigated in partially recognisable tasks such as the present soccer-task.

A particular methodology is advocated for future research on factors influencing the illusion of control because the thesis produced supporting evidence for the theoretical explanation on which the methodology is based. According to this explanation, the illusion of control is a by-product of problem-solving in gambling environments and has two variants. When the problem-solving is informed by the gambler's fallacy and other beliefs about the physical world, the associated illusion of control can be termed an illusion of primary control. Correspondingly, when the problem-solving is informed by beliefs about supernatural agents such a luck and God, the associated illusion of control is 'secondary'. This conceptualisation of the illusion of control can inform the design of future surveys of erroneous gambling-related beliefs and has implications for the treatment of problem-gambling through the reversal of erroneous gambling-related beliefs. Most critically, the conceptualisation suggests that further research is needed into methods of reversing quasi-religious beliefs about supernatural phenomena.

Empirical work needs to be carried out to examine the potential distinction between two sub-types of the illusion of primary control – the illusion based on the gambler's fallacy and the illusion based on other beliefs about non-supernatural phenomena. Experiments could seek to replicate the present finding of higher perceived control following an ascending success-slope using a roulette-style experimental task or any other task where the gambler's fallacy is the only source of relevant beliefs not relating to supernatural forces. If a different success-slope or set of success-slopes is found to be dominant with respect to the associated level of inferred control, there would be grounds for defining the illusion of gambler's-fallacy-based control as a separate construct. The effects success-frequency and win-amount on perceived control in roulette-type tasks need to be explored and compared to the present findings for the same reason.

Appendices for Chapter 6

Appendix 6A

This appendix examines the effect of individual differences in win-amount on perceived control. As in the main paper, the analyses involved hierarchical regressions in which DBC score was the predictor variable at the first step and the variable of interest (final win-amount) was a predictor at the second step. Three regressions of this kind were conducted involving each of the following dependent variables: perceived primary control, perceived secondary control and score on the traditional measure. The results are presented in Table 6A.1, where it can be seen that perceptions of both primary and secondary control increased significantly with the final win-amount, whereas scores on the traditional measure were not affected.

Notably, when the first two regressions were conducted with slightly different measures of perceived primary control and perceived secondary – measures derived from a factor analysis of an item set from which the 'Chance' item was excluded (see Appendix 3B) – variations in win-amount affected perceived secondary control but not perceived primary control. The inconsistency might be due to the fact that the illusion of primary control was measured less reliably than the illusion of secondary control, which was defined by more items following the factor analysis.

Table 6A.1. Hierarchical regression analyses of the influence of gambling-related beliefs and final win-amount on (a) ratings of perceived primary control, (b) ratings of perceived secondary control, and (c) scores on the traditional measure (N = 96)

(a) Perceived primary control

Step	Predictors	*B*	*SE B*	β	*t*	*p*	Adj R^2	Sig. *F* change
1	Constant	-1.58	.69				.32	
	DBC total	.07	.01	.56	6.63	<.001		
2	Constant	-2.27	.77					
	DBC total	.07	.01	.56	6.73	<.001	.35	.05
	Win amt.	.00	.00	.17	1.97	.05		

(b) Perceived secondary control

Step	Predictors	*B*	*SE B*	*β*	*t*	*p*	Adj R^2	Sig. *F* change
1	Constant	-.66	.89				.16	
	DBC total	.06	.01	.42	4.43	<.001		
2	Constant	-1.69	.97					
	DBC total	.06	.01	.42	4.52	<.001	.20	.02
	Win amt.	.00	.00	.21	2.32	.02		

(c) Score on traditional measure

Step	Predictors	*B*	*SE B*	*β*	*t*	*p*	Adj R^2	Sig. *F* change
1	Constant	-1.23	.55				.24	
	DBC total	.05	.01	.49	5.40	<.001		
2	Constant	-1.69	.62					
	DBC total	.05	.01	.49	5.44	<.001	.26	.10
	Win amt.	.00	.00	.15	1.64	.10		

Appendix 6B

Success-slope conditions were examined for signs of perceived learning, which might express itself in decreasing variability of responding as participants gradually identify and settle on what appears to be an effective strategy. Here, behavioural variability in the first 24 trials was compared to behavioural variability in the second 24 trials.

One behavioural variable examined across time was the number of voluntary player profile changes. A Repeated Measures ANOVA was conducted, with Time (Trials 1-24 vs. Trials 25-48) as the repeated-measures predictor and Success-slope Condition as a between-subjects predictor. The analysis revealed a main effect of Time ($F(1,330) = 5.44$, $p = .02$, ${}_p\eta^2 = .01$), and a significant Time x Success-slope interaction ($F(3,330) = 10.41$, $p < .001$, ${}_p\eta^2 = .09$). As indicated in Figure 6B.1(a), the main effect of time was negligible, whereas the interaction reflected the ‘ascending’ group’s tendency to reduce the number of player profile changes made over time. A related samples *t*-test showed that the difference between the mean number of player profile changes in the first 24 trials of the ‘end’ condition was significantly larger than the mean number of player profile changes in the second 24 trials of that condition ($t(78) = 5.64$, $p < .001$). Similar *t*-tests for the other conditions did not show significant results.

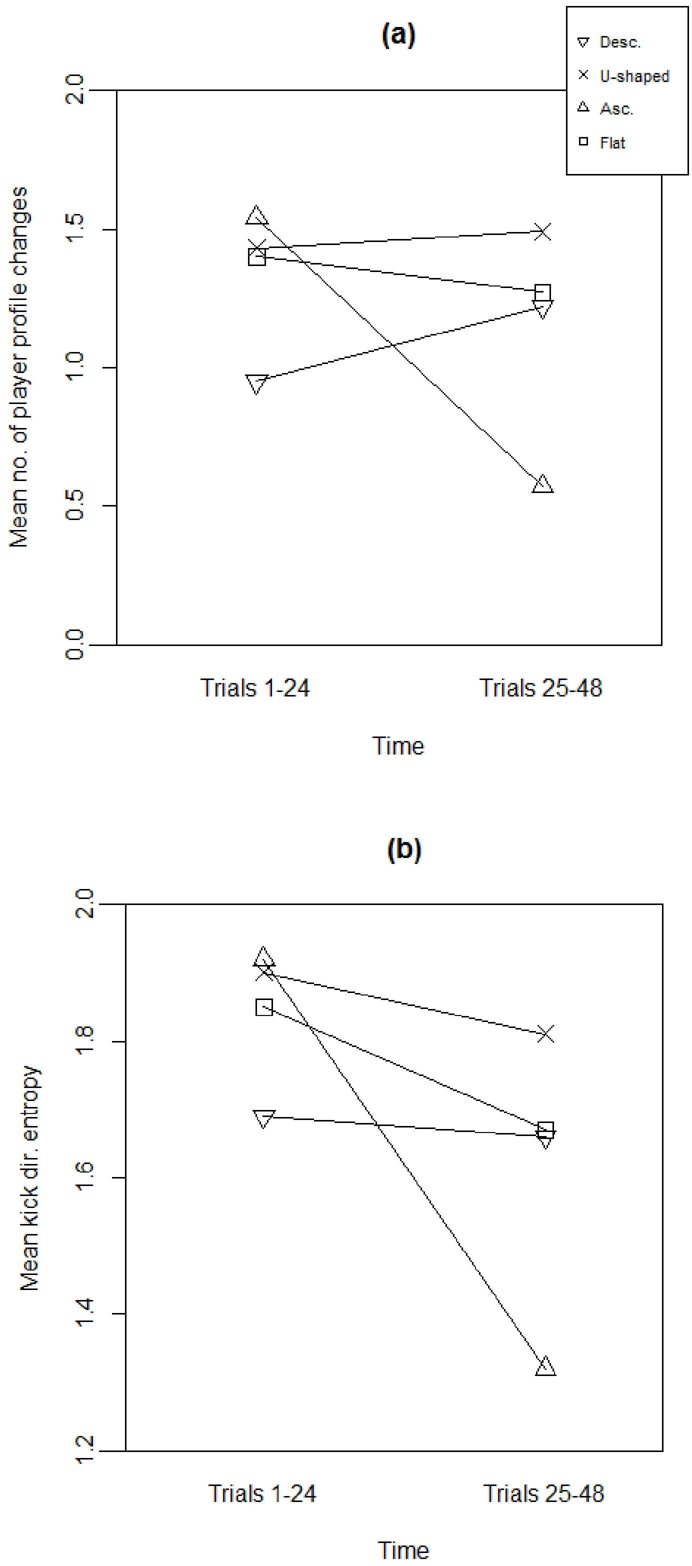


Figure 6B.1. Degree of variability in (a) player profile choices and (b) kick direction choices across time and success slope conditions.

The other behavioural variable subjected to analysis across time was the entropy of kick direction choices. Entropy can be defined as an index of the amount of information needed to describe the values assumed by a variable (Shannon, 1948). The greater the variability in values, the more information is needed, and, thus, the greater the entropy. The formula for computing entropy, $H(X)$, is as follows:

$$H(X) = -\sum_{i=1}^{n} p(x_i) \log_b p(x_i)$$

In the case of kick direction choices, n equalled 5 because there were five possible directions. For each time period (Trials 1-24, Trials 25-48), $p(x_i)$ was the percentage of trials on which kick direction i was selected. Computing entropy for the time period involved summing $p(x_i)$ for all values of i (i.e., for all five kick directions). A log base (b) of 2 was selected to make the computed entropy interpretable in terms of binary 'bits' of information. Higher kick direction entropy indicated higher rates of switching between the possible directions.

The results pertaining to kick direction entropy largely mirrored those obtained for the number of player profile changes. The Repeated Measures ANOVA with Time as the repeated-measures predictor, Success-slope Condition as a between-subjects predictor and Kick Direction Entropy as the outcome variable revealed a significant Time x Success-slope interaction ($F(3,330) = 19.64$, $p < .001$, ${}_p\eta^2 = .15$). As Figure 6B.1(a) illustrates, decreasing entropy in the 'ascending' condition was the source of the effect.

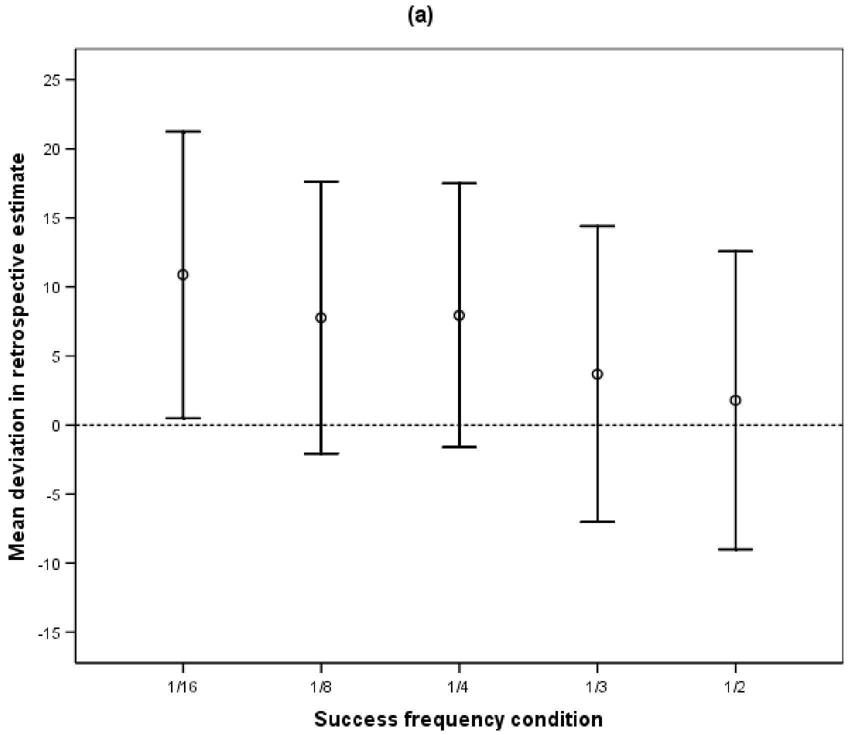
In contrast to the player-profile-change results, Time had a main effect that was not negligible in terms of effect size ($F(1,330) = 66.00$, $p < .001$, ${}_p\eta^2 = .17$). Follow-up t-tests correspondingly revealed significant time-based entropy decreases not only in the 'ascending' condition ($t(78) = 7.89$, $p < .001$), but also in the 'U-shaped' and 'flat' conditions ($t(85) = 2.33$, $p = .02$, and $t(83) = 3.12$, $p = .002$, respectively). The direction of the Time effect suggests that, alongside learning in the 'ascending' condition, kick direction variability was affected by boredom or fatigue.

Appendix 6C

For the explanation of some success-frequency-estimate patterns in terms of the 'over-under effect' to hold, evidence is needed that, in the context of the soccer-themed gambling task, 1/6 is indeed a success-frequency subject to overestimation, unlike some higher frequencies. Unpublished data from the study on success-frequency (Paper 1) can be used for this purpose. The study featured five success-frequency conditions, and the data of interest concerns prospective and retrospective success-frequency estimates across conditions. The pattern of estimates across conditions could be considered evidence for the 'over-under effect' if it suggests that (a) participants systematically overestimated lower frequencies while underestimating higher ones, and (b) 1/6 was among the overestimated frequencies.

Figure 6C.1 shows the mean deviation of retrospective[20] and prospective success-frequency estimates from the objective success-frequency level across conditions. The deviation levels were calculated by subtracting the true success-frequency from the estimate in each case, meaning that positive numbers indicate overestimation, whereas negative numbers indicate underestimation. Even though the confidence intervals around the means suggest that, in all conditions, success-frequency was neither overestimated nor underestimated, the means did follow an 'over-under' pattern. Specifically, frequencies below 1/3 tended to be overestimated, whereas frequencies of 1/3 and above were estimated accurately. By implication, 1/6 would be among the overestimated frequencies.

[20] No consideration was given to the effects of whether the retrospective estimate pertained to 'goals' or 'misses' because, while this variable was manipulated in this study in the same way as in the success-slope study, the question's framing had no effect.



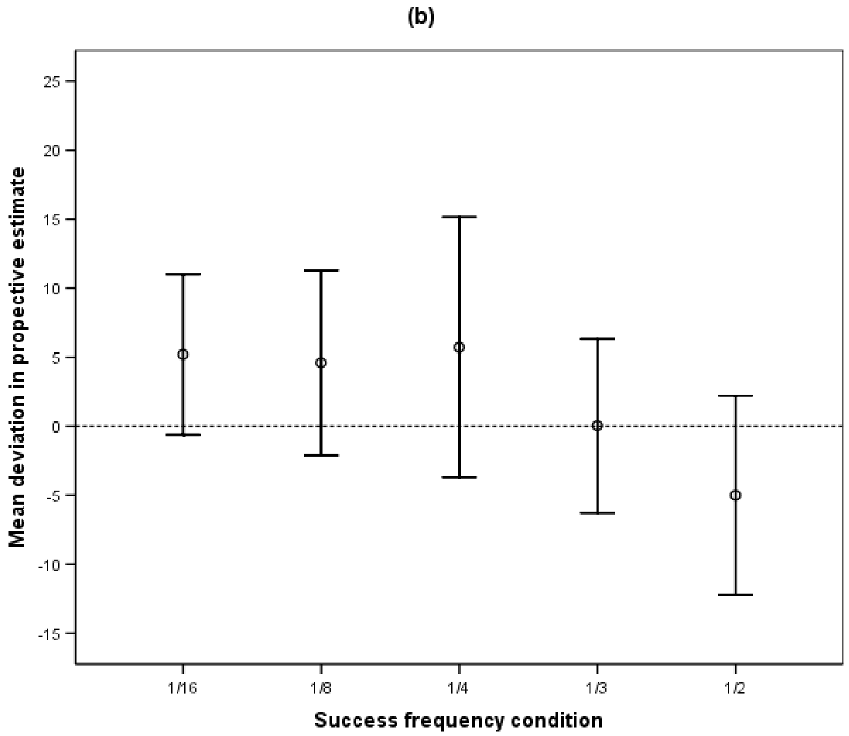


*Figure 6C.1. The extent to which estimates of (a) retrospective success-frequency and (b) prospective success-frequency deviated from the objective success-frequency across success-frequency conditions (*N *= 97; study described in Chapter 3)*

Next, a preliminary test of this ‘over-under’ (or, more precisely ‘over-accurate’) pattern was conducted. The mean deviation level of participants in conditions with a success-frequency less than 1/3 (i.e., conditions featuring a success-frequency of 1/4, 1/8 or 1/16) was calculated and compared to zero using a Wilcoxon signed-rank test. The same was done for the mean deviation level of participants in conditions featuring success frequencies of 1/2 and 1/3. Assuming a genuine ‘over-accurate effect’, a significant difference (overestimation) was expected in the lower frequency conditions, and no difference (accuracy) was expected in the higher frequency conditions. The results were broadly consistent with these expectations. For retrospective estimates, mean deviation in the lower frequency conditions represented a significant departure from zero (p = .004), and this was not the case in the higher-frequency conditions (p = .73). For prospective estimates, mean deviation in the lower frequency conditions represented a marginally non-significant departure from zero (p = .06), while the difference between zero and estimates in the higher-frequency conditions was definitively non-significant (p = .22).

This evidence that a success-frequency of 1/6 would be underestimated in the soccer task is a useful starting point for further testing but it is only preliminary. More formal analyses of accuracy across success-frequency conditions could be carried out in future, involving, for example, the fitting of a non-linear distribution that intersects with the line $y = 0$ (i.e., complete accuracy) at a point where x, the objective success-frequency, equals 1/3.

Appendix 6D

This appendix uses exploratory factor analysis (EFA) to test predictions of the explanation with respect to the raw dataset in Paper 3. One prediction is that, once items relating to the belief that luck is cyclical are removed from the dataset, the remaining items should be described by two latent factors. The second prediction is that the factors should be defined by the same items that were predicted to define the two latent factors in the CFA – that is, items expressing the gambler's fallacy and beliefs in the supernatural, respectively.

Prior to the analysis, it was ascertained that the 62 survey items of interest (all but the eight items in the 'cyclical luck' sub-category) satisfied the assumptions of the analysis (KMO = .96; Bartlett's test: $\chi^2(1891) = 10966$, $p < .001$; all initial communalities > .4). When the items were subjected to Principal Axis Factoring, visual inspection of the scree plot suggested a two-factor solution. Table 6D.1 shows the items that came to define each factor after a direct oblimin rotation. Factor 1 appeared to reflect the illusion of primary control, in that it included nine of the 10 items the main paper categorised as relating to 'negative recency' considerations, 27 of the 31 items labelled expressions of a belief about 'systems of play', and three out of five 'persistence' items. Meanwhile, Factor 2 corresponded to the illusion of secondary control in that it was defined by all eight items relating to the use of 'rituals' and four of the eight items relating to the 'omniscience and power' of supernatural agents.

This result was consistent with the explanation's predictions, except that, as the table also indicates, some item loadings were inconsistent with assumptions made in the main paper. Namely, the factor expressing the illusion of primary control (Factor 1) was defined by four items that were, in the main paper, classified instances of the 'omniscience and power' belief associated with the illusion of secondary control. Likewise, the illusion-of-secondary-control factor (Factor 2) was defined by seven items assumed to be instances of the illusion of primary control in the main paper. Even with these minor inconsistencies, the explanation's proposal regarding the two variants of the illusion of control received broad support from the EFA.

Table 6D.1. Factor loadings produced by a PAF analysis with oblimin rotation for the survey items not expressing belief in 'cyclical luck' (N = 327)

Item*		Categorisation in main paper	Factor loading F1 Illusion of primary control	Factor loading F2 Illusion of secondary control
1.	The longer I've been losing, the more likely I am to win.	Primary: Negative recency	.62	
2.	I should keep the same bet... because it is bound to win.		.62	
3.	...I don't want to miss a win.		.44	
4.	...I must maintain that strategy or plan because I know it will eventually come through for me.		.70	
5.	I have some control over predicting my gambling wins.		.34	
6.	If I keep changing my responses, I have less chances of winning...		.70	
7.	Losses... are bound to be followed by a series of wins.		.44	
8.	The thought that a win has to be coming soon keeps me gambling...		.73	
9.	Sometimes I feel that I can keep winning because I have learned to predict the next random thing the machine is going to do.			-.47
10.	Winning in poker machine gambling is a matter of knowing how random patterns work.		.55	
11.	I will be more successful if I have a system for playing poker machines.	Primary: Systems of play	.59	
12.	A good poker machine, roulette or dice gambler is like a sportsperson who knows winning plays and when to use them.		.43	
13.	There are secrets to successful gambling that can be learned.		.48	
14.	Show me a gambler with a well-planned system and I'll show you a winner.		.34	
15.	The more familiar I am with poker machine gambling, the more likely I am to win.		.69	
16.	One should pay attention to lottery numbers that often win.		.49	
17.	A game of chance is a contest of wills between the game and the player.		.59	
18.	Playing poker machines is a form of competition between the player and the machine.		.46	

Item*		Categori-sation in main paper	Factor loading F1 Illusion of primary control	F2 Illusion of secondary control
19.	My choices or actions affect the game...	Primary: Systems of play (cont.)	.47	
20.	... gambling wins are evidence that I have skill and knowledge...		.56	
21.	My knowledge and skill in gambling contribute to the likelihood that I will make money.		.46	
22.	I have more skills and knowledge... than most people who gamble.		.26	-.22
23.	I am pretty accurate at predicting when a win will occur.			-.50
24.	I should keep track of previous winning bets...		.52	
25.	... "near misses" or times when I almost win remind me that if I keep playing I will win.		.67	
26.	I think of poker machine gambling as a challenge.		.55	
27.	When I have a win once, I will definitely win again.		.53	
28.	A series of losses will provide me with a learning experience...		.40	-.32
29.	... I can beat the system.		.36	
30.	If I lose it's because something unforseen has happened.			-.49
31.	... I can win if I follow my strategies.		.53	
32.	Identifying a pattern helps...		.57	
33.	The chances of winning improve after a near win...		.51	
34.	When I've lost it's because I've made a hasty decision or didn't concentrate.			-.39
35.	The way in which I press the buttons... can influence the outcome.			-.36
36.	Winning... is all about knowing the right time to get on the machine.		.67	
37.	There is a definite type of person who has big wins at gambling.		.58	
38.	... it is important to know how to maintain a winning streak when one comes around.		.73	

Item*		Categori-sation in main paper	Factor loading F1 Illusion of primary control	F2 Illusion of secondary control
39.	... it is important to know how to change the flow of the game when facing a losing streak.	Primary: Systems of play (cont.)	.52	
40.	The machines pay out more at different times of day.		.44	
41.	You can win more... if you know how to make good use of free spins.		.74	
42.	Where I get money to gamble doesn't matter because I will win and pay it back.	Primary: Persistence		-.54
43.	In the long run, I will win more money than I will lose gambling.			-.41
44.	If I continue to gamble, it will eventually pay off and I will make money		.50	
45.	If I lose money gambling, I should try to win it back.		.50	
46.	... gambling success requires dedication and a willingness to invest some money.		.40	
55.	...fate is against me when I lose.	Secondary: Power and omniscience	.43	
56.	There is useful information in my horoscope.			-.47
57.	Some gamblers are just born lucky.		.57	
58.	Following lucky signs can help me win.			-.58
59.	I have the psychic ability to predict a winner.			-.64
60.	Bad vibes from people around me cause me to lose.		.42	-.33
61.	I make the right choice because I'm generally lucky.		.32	-.34
62.	... the good or bad luck of other players could rub off on me.		.40	-.35
63.	There may be magic in certain numbers.	Secondary: Rituals		-.66
64.	... I wear lucky clothes or jewellery.			-.63
65.	I can improve my chances of winning by performing special rituals.			-.75
66.	I like to carry a lucky coin, charm or token...			-.73
67.	I have a "lucky" technique that I use...		.31	-.43

Item*		Categori-sation in main paper	Factor loading F1 Illusion of primary control	F2 Illusion of secondary control
68.	There are certain things I do when I am betting; for example, tapping a certain. number of times, holding a lucky coin in my hand...	Secondary: Rituals (cont.)		-.64
69.	... I have the power to 'will' my desired outcomes to come up.			-.40
70.	You never know what might happen if you don't perform certain rituals...			-.57
Variance explained after rotation			21%	18%
Correlation between factors			-.73	

Note: Factor loadings of magnitude <.3 are suppressed (except for item 22)
* For exact item wording, see Appendix 5A

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