



An Empirical Study of the Pathway Model Link Between Cognitive Distortions and Gambling Problems

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Abstract

This research empirically tests the relationship between gambling-related cognitive distortions and the development of gambling problems. In two separate studies using methodologies designed to support non-experimental causal inference, we demonstrate that holding false beliefs about gambling experiences is related to current and future risk of developing problems with gambling. In our first study, we use an instrumental variable estimation strategy on an internet sample ($n = 184$) and observe a statistically significant relationship between Gamblers' Belief Questionnaire scores and measures of loss chasing, overspending, and gambling problems. These findings were robust to linear and ordinal estimation strategies and multiple model specifications. In our second study, we examine five-year prospective longitudinal data ($n = 1,431$) to validate our initial findings and test whether irrational thoughts are also related to future problems with gambling. While controlling for current fallacies, we find that past Gambling Fallacies Measure scores are related to present gambling problems across two survey waves. The effect size of each of the past fallacy levels is roughly half of the effect size of present levels, suggesting meaningful impacts. Our findings support the Pathways Model of Problem and Pathological Gambling.

Keywords Cognitive distortions · Gambling disorders · Gambling fallacies

Introduction

The current understanding of gambling research suggests that individuals with gambling problems often hold false beliefs about their likelihood of winning or influencing game outcomes (Fortune & Goodie, 2012; Hodgins et al., 2011). Correcting these cognitive distortions is believed to be an important part of treatment programs (Hodgins et al., 2011; Petry et al., 2017; Yau & Potenza, 2015), but despite the importance of addressing these schema in treatment, cognitive distortions' role in contributing to the formation of problems with

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gambling is unclear. For instance, most individuals hold some distorted beliefs but do not develop problems with gambling (Welte et al., 2015).

The leading model of problem gambling etiology, the Pathways Model of Problem and Pathological Gambling (Pathways Model, Blaszczynski & Nower, 2002), proposes that cognitive distortions precede overconsumption and loss chasing, which subsequently can lead to problems. However, empirical evidence of this link is primarily retrospective and correlational since the related habits may take a long period of time to develop. Validation of this proposed path is an important question to gambling studies, as it has implications for prevention programs and appropriate responsible gambling practices in product design and marketing.

This research contributes to the literature by empirically examining the relationship between gambling-related cognitive distortions and the development of gambling problems. The contribution is methodological and empirical, as we use two estimation strategies that are novel to the existing literature. In our first study, we use an instrumental variable approach to correct for endogeneity biases in the impact of cognitive distortions on gambling. This allows us to improve our understanding on the direction of the effect and potential confounding issues from missing variables. In our second study, we use panel data from a multiyear longitudinal study of adults to understand whether cognitive distortions are related to gambling problems in future periods.

As gambling grows in social influence, it is important to understand how product and design choices will contribute to social harms and what steps can be taken to improve consumer protection. If cognitive distortions contribute to the risk of developing a gambling problem, regulators and other stakeholders should invest in prevention programs that specifically target these false beliefs. In addition, operators can make better product and design choices that minimize the likelihood that individuals will hold false beliefs about their likelihood of winning or influencing outcomes.

Literature

Cognitive Distortions

Gambling is an activity that spans several large industries including casinos, pokies, pachinko parlors, video lottery terminals, sports wagering, lottery games, and online gaming. Gambling-related cognitive distortions are a set of loosely related errors in human decision-making that are connected by their relationship to the gambling consumption experience and false perceptions about individuals' ability to predict or control outcomes that are determined by chance (Blaszczynski & Nower, 2002; Fortune & Goodie, 2012; Goodie & Fortune, 2013; Hodgins et al., 2011; Toneatto, 1999).

Much of the early research on gamblers' cognitive distortions derived from 'think-aloud' methods, where gamblers expressed their thoughts while gambling or performing related tasks (Gaboury & Ladouceur, 1989; Griffiths, 1994; Ladouceur et al., 1988; Sharpe, 2002). Analysis of transcripts from these studies revealed several categories of maladaptive thoughts, which conflicted with an objective assessment of reality. For example, irrational verbalizations in Ladouceur et al. (1988) included misattributions about skill while playing a slot machine, "I'm getting good at this game. I think I've mastered it" (p.414).

Gambling related biases include a class of heuristics and other misattributions that emerge throughout the gambling experience (Fortune & Goodie, 2012), which lead to false

beliefs by the player about the likely outcomes of their play (Hodgins et al., 2011). These beliefs often do not correct over time or experience, and are related to persistence in gambling (Billieux et al., 2012). Across a range of logic or probability tasks, individuals often give irrational responses due to a use of heuristics instead of deliberate reasoning processes (Kahneman et al., 1974). Although the use of heuristics can provide fast choices that do not burden limited executive resources, they can systemically fail to provide reasonable decisions (De Neys & Goel, 2011; Stanovich, 2000).

Several validated scales of gambling cognitive distortions were developed in the early-2000s (Goodie & Fortune, 2013), leading to many studies that demonstrate a correlation between distorted thinking and gambling problems across multiple populations (Cunningham et al., 2014; Joukhador et al., 2003; Raylu et al., 2016; Xian et al., 2008). Etiological models of gambling problems, most notably the “Pathway Model”, propose a causal role of cognitive distortions in the development of gambling disorders (Blaszczynski & Nower, 2002; Hodgins et al., 2011; Sharpe, 2002). Cognitive distortions are described in this literature as false beliefs that lead to wagering, and therein, classical and operant conditioning effects from the reward and punishment structure of games. This further leads to increased frequency of play and exposure, and potential development of more pervasive cognitive schema that shape and distort consumers’ experiences with gambling.

One of the largest categories of distorted thinking by gamblers is related to availability heuristics, which are biases where events that are more easily recalled in memory are perceived as more likely to occur (Tversky & Kahneman, 1973). These include gamblers drawing illusory correlations between events, such as salient environmental features or the impact of superstitious beliefs, talismans, and behaviors (Fortune & Goodie, 2012). It also includes biases from selective memory, including more prominent recall of own and others’ wins rather than losses (Griffiths, 1994; Hodgins et al., 2011). There is some evidence that availability heuristics respond to commercial practices, such as advertisement of recent lottery winners at local stores drawing more customers (Guryan & Kearney, 2008) and making wins more salient than losses through slot machine sounds (Dixon et al., 2014). These types of effects appear to drive use of superstitious elements in marketing and design choices.

A second class of errors is related to the representativeness heuristic, where randomly distributed small sequences of numbers are believed to be representative of the distributions from which they are derived (Tversky & Kahneman, 1971). This set of errors includes the hot hand fallacy, which is a false belief that past success in randomly determined events is indicative of future success. This cognitive distortion has most notably been reinforced in slot machines, where multiline games respond with lights and sounds like a win, despite a net loss occurring across multiple simultaneous wagers. Those outcomes, known as ‘losses disguised as wins’, are believed to be associated with overestimation of win rates, and are in machines found to be preferred by problem gamblers (Barton et al., 2017). The gambler’s fallacy is also an error in representativeness. It refers to a mistaken belief that if an outcome has occurred more often in the past, it will occur less often in the future, despite the trials being statistically independent (Croson & Sundali, 2005). Observational studies confirm that consumers bet consistently with the gambler’s fallacy and hot hand beliefs (Croson & Sundali, 2005; Xu & Harvey, 2014).

Perhaps the most frequently reinforced cognitive distortion in the gambling industry is the illusion of control. This bias refers to an erroneous belief by players that they can influence games of chance through skillful behavior or decisions, or that they have influence over chance elements in games of mixed skill and chance (Ladouceur et al., 1984; Langer, 1975). Many illusions appear due to core aspects of the games. For example,

craps games require a player to roll dice, and players tend to place higher and more risky wagers on their own rolls than rolls by other players (Davis et al., 2000). Similarly, sports fans may believe that their knowledge about teams or players will give them an advantage in placing sports wagers. Illusions of control are also reinforced through unnecessary game elements or other firm practices. For example, lottery advertisements often imply gamblers have control over outcomes by picking numbers (Miyazaki et al., 2001), and electronic gaming machines have features like stop buttons that appear to change reel outcomes, but have no actual influence on outcomes that were determined before the button was pressed (Inoue, 1998). A related design feature that has received attention in both slot machine and instant ticket research is the artificial near-miss, where losses are purposefully manipulated to appear close to a winning outcome, rather than a randomly distributed loss appearance (Muir, 2009; Stange, et al., 2017). Near misses are interpreted by gamblers as progress in mastering the game, and are therefore viewed as biases in illusion of control (Clark, 2010; Clark et al., 2009; Griffiths, 1991).

A small number of studies have attempted to estimate the relationship between cognitive distortions and gambling problems using longitudinal estimation strategies. Two studies used generalized estimating equations, finding small but significant effect sizes (Leonard & Williams, 2016; Schulte et al., 2021) but also noted concerns about reverse causality in the relationship. One study used logistic regression (Nicholson et al., 2016), which likely led to dependent observations that are nested within subjects, making inference unreliable.

Hypotheses

Our hypotheses closely follow propositions in the Pathways Model literature (Blaszczynski & Nower, 2002), which suggests that gambling-related cognitive distortions lead to excessive loss chasing and overspending, and then to subsequent problems with gambling. A behavioral response to irrational beliefs about winning by gamblers is likely to be an increase in play volume – gamblers that falsely believe that they can win at gambling may be more likely to continue to play. This may lead to instances of overspending and attempts to win back money that results in loss chasing. The emotional, social, and financial consequences of this behavior and increased volume may lead to more pervasive problems with gambling.

H1a Gambling-related cognitive distortions lead to increases in loss chasing.

H2a Gambling-related cognitive distortions lead to wagering more than an individual can subjectively afford to lose.

H3a Gambling-related cognitive distortions lead to current gambling problem severity.

Cognitive distortions may be deeply held, and we may expect their effects to perpetuate in the future. Since addictions may develop over time as a result of conditioning effects from gambling or ongoing personal and social consequences (Blaszczynski & Nower, 2002), we expect that cognitive distortions will also be indicative of future risks.

H1b Gambling-related cognitive distortions lead to increases in future loss chasing.

H2b Gambling-related cognitive distortions lead to wagering more in the future than an individual can subjectively afford to lose.

H3b Gambling-related cognitive distortions lead to future gambling problem severity.

Study 1

Cognitive distortions in gambling are formed and reinforced over time. The usefulness of experimental design to evaluate impacts on behavior and gambling problems is therefore constrained. To test H1a, H2a, and H3a, we employ an instrumental variable method in Study 1 that allows us to control for arbitrary forms of endogeneity that would appear in ordinary linear regressions, such as reverse causality or omitted variable bias.

Methods

Due to the low prevalence of persons with gambling problems in the general population, which is estimated at less than 1% of adults (Kessler et al., 2008), we recruited gamblers through the Amazon Mechanical Turk (MTurk) panel. Online panels are noted to have over four times the incidence of persons with gambling disorders than random-digit dialed samples (Lee et al., 2015). Most workers are jointly motivated by financial compensation and enjoyment of the tasks (Paolacci & Chandler, 2014).

Participants in this study were restricted to those with an MTurk approval rating of at least 95 percent (Goodman et al., 2013; Peer et al., 2014). To further reduce social desirability bias, respondents were told their data would be anonymous and the specific nature of the research question was concealed (Paolacci & Chandler, 2014). Participants were English speaking North Americans of the legal gambling age that had lived in or visited the jurisdictions that contain all of the games discussed in the study (Nevada, New Jersey, Connecticut, and California) in the past 12 months. A total of 232 respondents were recruited, and 48 responses were removed due to failing at least one of two attention checks or not completing the survey. The sample was more male (67.93%) with a mean age of 34.0 ($SD=9.3$). Study procedures were approved by the [redacted] Human Research Ethics Committee.

We estimate linear instrumental variable models using questions of loss chasing, overspending, and overall problem gambling severity index scores as the dependent variable, and we estimate ordered probit models using problem gambling severity index categories as the dependent variable. Instrumental variable methods can improve the consistency of empirical models when there are endogenous effects as they simulate random assignment when instruments are sufficient strong (Angrist & Imbens, 1995; Angrist et al., 1996; Baiocchi et al., 2014; Rassen et al., 2009). These corrections are important to this model, as it seems likely that estimates will be biased by omitted variables (e.g. genetic predisposition) or reverse causality. Instrumental variable models are often used in social sciences to infer causality when there are unmeasured confounding variables (Lousdal, 2018). We estimate the models using Stata 15.1 and its extended regression models package (StataCorp LLC, 2017).

The study was approved by the [redacted] Human Research Ethics Committee and all participants provided informed consent. Replication data will be made available by the authors for institutional review board approved studies.

Measures

The Gamblers Belief Questionnaire We measure distortions using the *Gamblers Belief Questionnaire* (GBQ), a validated and self-administered psychometric measure of gambling cognitive distortions (Steenbergh et al., 2002; Winfree et al., 2015). The GBQ was originally validated through five studies described in Steenbergh et al. (2002), and further studies have found it to be a valid scale (Marchetti et al., 2016; Philander et al., 2019; Winfree et al., 2013; Wong & Tsang, 2012). The scale includes 20-items measured on a 7-point scale (1 = strongly agree, 7 = strongly disagree), which are reverse coded and summed ($m = 71.12$, $sd = 9.48$). Higher scores indicate higher levels of cognitive distortions.

The Problem Gambling Severity Index Gambling disorders are measured using the problem gambling severity index (Currie et al., 2013; Ferris & Wynne, 2001). The index is a self-reported epidemiological measure of gambling addiction, designed to measure harmful consequences of gambling behavior in the general population. The index has been validated across multiple populations (Currie et al., 2013; Holtgraves, 2009; Jackson et al., 2010; Miller et al., 2013; Orford et al., 2010; Sharp et al., 2012) and in multiple languages (Loo et al., 2011; Lopez-Gonzalez et al., 2018; Marchetti et al., 2016; So et al., 2019).

Two of the nine items from the index are used to test H1a and H2a, respectively: (1) [thinking about the last 12 months] “When you gambled, did you go back another day to try to win back the money you lost?” (Loss Chasing); and (2) “Have you bet more than you could really afford to lose?” (Overspending). Item (1) originally appeared in the fourth edition of the American Psychiatric Association’s diagnostic manual (American Psychiatric Association, 2012). Item (2) originally appeared in the South Oaks Gambling Screen (Lesieur & Blume, 1987). Both screens were developed for use with clinical populations. All items responses occur on a four-point Likert scale: 0, “Never”; 1, “Sometimes”; 2, “Most of the time”; or 3, “Almost always”. Item scores are summed and total scores range from 0 to 27, with four interpretative categories (Currie et al., 2013): 0, non-gambler/non-problem gambler ($n = 83$, 45.11%); 1–4, low-risk gambler ($n = 48$, 26.09%); 5–7, moderate-risk gambler ($n = 13$, 7.07%); and > 7, problem gambler ($n = 40$, 21.74%).

Skill and chance variables (instruments) Respondents were asked to order a series of gambling games (e.g. slot machines) and non-gambling games (e.g. chess) along a 100-point scale from all skill (0) to all chance (100), which we exploit to form our instrumental variables. The instrumental variables are the difference in an individual’s perceived slot machine skill/chance ($m = 89.93$, $sd = 14.65$) from its mean score across all participants (perceived slot skill), and the difference in an individual’s perceived poker skill/chance ($m = 19.77$, $sd = 30.67$) from its mean score across all participants (perceived poker skill). Intuitively, our instrument exploits subjective differences in a game that objectively has no skill component, slot machines, from a game that objectively has a skill component, poker. We propose that individual’s experiences playing, observing, or otherwise learning about particular games are likely to influence their potentially distorted thoughts on skill and chance elements of that game, and therein impact their overall cognitive distortions in gambling as measured by the GBQ.

Slot machines are games of pure chance, and we expect respondents with stronger cognitive distortions to overvalue the role of skill in slot machines relative to other respondents. Poker is a game of mixed skill and chance, and with the slot machine

instrument capturing illusion of control effects, we expect the poker variable will capture further cognitive distortions related to an undervaluation of the role of skill in poker, either through attributing negative outcomes to luck (i.e. attribution bias) or viewing it as similar to other card-based table games (i.e. representativeness bias). We test the power of our instruments as part of our empirical analysis, and control for frequency of play of slot machines and poker.

Other variables Respondents are asked about frequency of play in various games over the past 12-months on a six-point Likert scale ranging from “Not at all in the past year” to “Daily”. Summary statistics of these variables are provided in Table 1. Respondents are asked several demographic questions, including age, gender identity, race, income level, and education level. Respondents were mostly ‘White’ ($n=105$, 57.07%), followed by ‘Asian’ ($n=34$, 18.48%), ‘American Indian or Alaskan Native’ ($n=16$, 8.70%), ‘Hispanic, Latino, or Spanish origin’ ($n=15$, 8.15%), ‘Black or African American’ ($n=13$, 7.07%), and ‘Other’ ($n=1$, 0.54%). In terms of highest level of education, 26 individuals reported a Master’s degree (14.13%); 91 reported a Bachelor’s degree (49.46%); 36 reported an Associate’s degree (19.57%); and 31 reported a high school diploma or equivalent (16.85%). The median income category was \$50,000–\$70,000 per year, with three respondents not disclosing their income range.

Results

To test if the specific behavioral items related to H1a and H2a are implicated in the relationship with GBQ, we produce an ordered probit model with endogenous regressors for both dependent variables in Table 2. All model estimates imply a positive relationship between loss chasing and GBQ scores, supporting H1a. Similarly, we estimate a positive relationship between reported over-spending and GBQ, supporting H2a. After controlling for frequency of game play, gender, age, race, income, and education, and other endogenous effects, higher rated gambling cognitive distortions score are associated with higher likelihood to reply “Sometimes” or more, and a lower likelihood of reporting “Never”, as shown in the estimated marginal effects.

We further test the validity of our instruments in our linear two-stage least squares model estimating problem gambling severity index scores. We note that all models in this study have the same first-stage equation variables. The fully specified linear two-stage regression model (Table 3, Model 6) is statistically significant (adjusted $R^2=0.63$, $\chi^2(22, n=184)=619.97$, $p<0.001$). The perceived slot skill variable appears to be a good instrument ($\beta=-0.596$, $p<0.001$), while the perceived poker skill variable is not significant ($\beta=0.123$, $p=0.071$). We retain perceived poker skill as an instrument, as it is significant in the similar ordered regression model appearing in Table 4 ($\beta=0.330$, $p<0.001$), which is functional form that may better align with the distribution of the scale (Currie et al., 2013). Jointly, the instruments perform

Table1 Summary statistics of frequency variables

Variable	N	Mean	Std. Dev	Min	Max
Slot Machine Frequency	184	2.435	1.333	1	6
Poker Frequency	184	2.120	1.350	1	6
Video Game Frequency	184	4.152	1.656	1	6
Mobile Game Frequency	184	4.304	1.658	1	6

Table 2 Ordered probit with endogenous regressor – Loss chasing and overspending

	(1) DV: Loss Chasing	(2) DV: Loss Chasing	(3) DV: Loss Chasing	(4) DV: Over-spending	(5) DV: Over-spending	(6) DV: Over-spending
GBQ	0.043*** (0.005)	0.047*** (0.006)	0.036*** (0.007)	0.056*** (0.006)	0.056*** (0.006)	0.046*** (0.006)
Slot play freq			0.445*** (0.107)			0.344*** (0.113)
Poker play freq			0.0717 (0.102)			0.107 (0.101)
Gender	No	Yes	Yes	No	Yes	Yes
Age group	No	Yes	Yes	No	Yes	Yes
Race	No	Yes	Yes	No	Yes	Yes
Income	No	Yes	Yes	No	Yes	Yes
Education	No	Yes	Yes	No	Yes	Yes
<i>First stage instrument estimates (DV: GBQ)</i>						
Perc. slot skill	–0.954*** (0.143)	–0.963*** (0.136)	–0.959*** (0.138)	–0.950*** (0.141)	–0.955*** (0.135)	–0.951*** (0.137)
Perc. poker skill	0.357*** (0.079)	0.349*** (0.079)	0.352*** (0.079)	0.360*** (0.077)	0.356*** (0.076)	0.359*** (0.076)
<i>Average marginal effects of GBQ</i>						
Never	–0.009***	–0.008***	–0.005***	–0.008***	–0.007***	–0.004***
Sometimes	0.003***	0.003***	0.002***	0.003***	0.003***	0.002***
Most of the time	0.004***	0.003***	0.002**	0.003***	0.002*	0.001**
Almost always	0.003**	0.002**	0.001*	0.002*	0.001**	0.001**

Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3 Linear regression–Problem gambling severity index score

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	OLS	2SLS	2SLS	2SLS
GBQ	0.154*** (0.013)	0.114*** (0.014)	0.045*** (0.015)	0.221*** (0.021)	0.187*** (0.031)	0.161** (0.050)
Slot play freq			1.755*** (0.415)			0.701 (0.579)
Poker play freq			0.874* (0.402)			0.142 (0.529)
Constant	− 6.660*** (0.772)	1.025 (2.246)	− 3.012 (1.861)	− 11.43*** (1.479)	− 6.817 (3.640)	− 7.681** (2.824)
Gender	No	Yes	Yes	No	Yes	Yes
Age group	No	Yes	Yes	No	Yes	Yes
Race	No	Yes	Yes	No	Yes	Yes
Income	No	Yes	Yes	No	Yes	Yes
Education	No	Yes	Yes	No	Yes	Yes
<i>First stage instrument estimates (DV: GBQ)</i>						
Perc. slot skill				− 0.954*** (0.145)	− 0.892*** (0.146)	− 0.596*** (0.148)
Perc. poker skill				0.357*** (0.079)	0.227** (0.078)	0.123 (0.068)
Observations	184	184	184	184	184	184
Adjusted R^2	0.510	0.601	0.703	0.412	0.515	0.578

Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

well. The F-test of weak identification = 15.740, exceeding the benchmark value of 10 (Sovey & Green, 2011; Staiger & Stock, 1997) and the estimated 15% maximal size of 11.59 (Stock & Yogo, 2005). The Sargan test statistic $\chi^2 = 0.202$, $p = 0.653$, failed to reject the assumption that perceived skill variables do not belong in the structural equation predicting problem gambling severity index scores (Sargan, 1958), supporting the other necessary condition. In all the linear models, higher GBQ scores are associated with higher problem gambling severity index scores, supporting H4.

In our ordinal models estimating problem gambling severity index groups, GBQ is statistically significant and the correct sign, supporting H3a. As shown in Table 4, across all marginal effect estimates, higher cognitive distortions are associated with a lower probability of belonging to the non-problem gambler category and a higher probability of belonging to one of the problem gambling risk categories. The endogenous ordered probit model instruments are all statistically significant, $p < 0.001$, again suggesting that the instruments are strong.

Study 2

Since the impacts of H1a, H2a, and H3a are likely to reinforce over time, we conduct analysis on a longitudinal data set in Study 2, to further validate the cross-sectional findings from Study 1 and test H1b, H2b, AND H3b. A longitudinal data set allows us to use

Table 4 Ordered regression—Problem gambling severity index group

	(1)	(2)	(3)	(4)	(5)	(6)
	OLogit	OLogit	OLogit	EOProbit	EOProbit	EOProbit
GBQ	0.071*** (0.009)	0.067*** (0.010)	0.044*** (0.011)	0.048*** (0.004)	0.049*** (0.004)	0.039*** (0.005)
Slot play freq			0.886*** (0.234)			0.369*** (0.109)
Poker play freq			0.399 (0.214)			0.182 (0.093)
Gender	No	Yes	Yes	No	Yes	Yes
Age group	No	Yes	Yes	No	Yes	Yes
Race	No	Yes	Yes	No	Yes	Yes
Income	No	Yes	Yes	No	Yes	Yes
Education	No	Yes	Yes	No	Yes	Yes
<i>First stage instrument estimates (DV: GBQ)</i>						
Perc. slot skill				−0.960*** (0.143)	−0.986*** (0.131)	−0.984*** (0.134)
Perc. poker skill				0.352*** (0.079)	0.328*** (0.076)	0.330*** (0.076)
<i>Average marginal effects of GBQ</i>						
Non-problem	−0.010***	−0.008***	−0.005***	−0.008***	−0.006***	−0.003**
Low-risk	0.001***	0.002***	0.002***	0.001***	0.002***	0.001***
Moderate risk	0.001***	0.001**	0.001**	0.001***	0.001**	0.001*
Problem	0.008***	0.005***	0.002***	0.006***	0.003***	0.001*

Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

methods to detect whether cognitive distortions have an impact on future gambling problems, across a multiyear period. We use secondary data from the Leisure, Lifestyle, & Life-cycle Project (LLLP, El-Guebaly et al., 2015), a high quality panel of gamblers and non-gamblers. This study was found to be exempt from review by [redacted].

Methods

The LLLP was a five-year prospective longitudinal study on the factors influencing change in gambling and problem gambling. A sample of 1808 participants from the province of Alberta were recruited, though we limit our focus to the adult sample ($n = 1,372$), where the retention rate was 76.2%. Six cases were removed that had values that were incompatible with the measures used. There were four data collection cycles in the study. Median time between cycles was 567 days, 649 days, and then 518 days. Further information about the sample collection procedure is available in Dataverse materials (El-Guebaly et al., 2015).

We estimate random and fixed-effect regression models, which enables us to examine the effects of cognitive distortions on responses to future gambling measures. Fixed-effect models control for static individual traits, and allows us to test for changes that occur over time, rather than cross-sectionally (Wooldridge, 2010), whereas random effects models

allow for individual heterogeneity that is constant over time and uncorrelated with the error term. We test for the appropriate model using the Hausman test (Hausman, 1978).

Measures

The Problem Gambling Severity Index We use the same variables as in Study 1, including items on Loss Chasing and Overspending.

Gambling Fallacies Measure Cognitive distortions are measured using the Gambling Fallacies Measure, a 10-item summative scale assessing several gambling-related fallacies, including the illusion of control and the gambler's fallacy (El-Guebaly et al., 2015). Respondents receive one point for every correct response they provide to a series of questions. The scale ranges from 0–10 with lower values indicative of greater fallacies.

Results

After estimating random and fixed-effect models, the Hausman tests suggest that random effects models are consistent and the most efficient relative to the fixed effect models using the problem gambling severity index, $\chi^2(3)=1.22$, $p=0.75$; loss chasing, $\chi^2(3)=1.73$, $p=0.63$; and overspending variables, $\chi^2(3)=1.28$, $p=0.73$. The regression output for both fixed and random effects models appear in Table 5. The random effects models reinforce our findings from Study 1 regarding H1a, H2a, and H3a and suggest that greater cognitive distortions are related to greater contemporaneous gambling problems, loss chasing, and overspending.

We also observe lagged effects of cognitive distortions on two outcome variables. Even when controlling for current fallacies, we find that past fallacies are related to present gambling problems across two survey waves. The effect size of each of the past fallacy levels is roughly half of the current fallacy levels, suggesting a meaningful effect and supporting H3b. In addition, we also observe one period lagged effect on overspending in the more efficient random effects model, supporting H2b. We find no evidence supporting H1b.

General Discussion

Our findings suggests that cognitive distortions may influence current and future gambling behavior. We find that the presence of gambling-related cognitive distortions is indicative of current loss-chasing and overspending by gamblers, even after controlling for endogenous factors such as omitted variable bias or reverse causality with an instrumental variable model. A similar relationship appears between cognitive distortions and gambling problems. Although prior research has shown a strong correlation between these items, our findings provide clearer evidence on the direction of relationship due to the ability of our empirical model to control for endogenous effects. These findings complement neuropsychological research in gambling disorders, where there is growing evidence that these processes are physiological and extend to other addictive substances and behaviors (Clark, 2014; Naqvi et al., 2014).

We further tested our findings in Study 2 using longitudinal data and a different cognitive distortion scale. We found evidence that past cognitive distortions are related to future gambling problems and overspending. Notably, these lagged effects are linked multiple years in the future, which is consistent with the Pathways Model that proposes a multistep

Table 5 Panel data regression models

	(1) Random Effects DV: PGSI Score	(2) Fixed Effects DV: PGSI Score	(3) Random Effects DV: Loss Chasing	(4) Fixed Effects DV: Loss Chasing	(5) Random Effects DV: Over-spending	(6) Fixed Effects DV: Over-spending
Fallacies	−0.149*** (0.036)	−0.143** (0.048)	−0.032*** (0.010)	−0.037* (0.015)	−0.035*** (0.009)	−0.037** (0.013)
Fallacies (1-period lag)	−0.082** (0.032)	−0.071 (0.0466)	−0.003 (0.009)	−0.008 (0.015)	−0.015* (0.008)	−0.020 (0.013)
Fallacies (2-period lag)	−0.075* (0.030)	−0.080* (0.041)	−0.014 (0.008)	−0.024 (0.0126)	−0.009 (0.007)	−0.017 (0.011)
Constant	3.048*** (0.356)	2.969*** (0.719)	0.509*** (0.075)	0.653** (0.223)	0.563*** (0.073)	0.665*** (0.195)
Observations	1,431	1,431	1,431	1,431	1,431	1,431
Adjusted R^2	.04	.04	.02	.02	.03	.03

Standard errors in parentheses. *PGSI*: Problem gambling severity index. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

journey from conditioning effects of the gambling product to addictive behaviors. We did not find evidence that loss chasing was indicative of future problems, which may suggest that it's a less consequential variable to developing long-term issues. It does appear likely that there is a pathway that connects cognitive distortions to long-term problems with gambling products, but the relatively weak effects on overspending and loss-chasing in future periods suggests that the mechanism may occur relatively quickly before it either resolves or perpetuates as gambling problems. These results are consistent with the Pathways Model and provide some direction in terms of the time period to consider for conditioning effects.

Implications for Policy and Practice

Many aspects of the consumer experience intrinsically reinforce maladaptive thoughts, which leads to irrational consumption decisions. Given our findings, operators in gambling industries should consider how product design and marketing communications may unnecessarily contribute to these errors in cognition. Several obvious candidates for change include the removal of artificial near misses, losses disguised as wins, and artificial game controls.

Interventions to educate consumers and the public of common distortions can be used to enable resistance to the development of erroneous cognitive schemata (Shaffer et al., 2016). If individuals can effectively rationalize likely consequences of consumption, they may be able to resist conditioning effects and consider other tactics more aligned with their long-term goals or wellness, such as leaving debit cards at home during casino visits. This may be particularly important for youth and young adults who do not have firmly established beliefs.

Given the evidence of widespread commercial practices that encourage distortions, substantial regulatory intervention may be appropriate. This could include restriction of advertisements or promotions that portray or encourage myths, and restriction of product design features. A reasonable starting point for regulation would be to minimize the presence of features that contribute to cognitive distortions but add little novelty to the gameplay experience for most players.

Limitations and Future Research

Due to the length of time required to develop cognitive distortions and problems with gambling, this study used instrumental and longitudinal data methods to test our hypotheses, rather than experimental data. Accordingly, typical caution should be used in interpreting findings that may be subject to model misspecification or related errors. Notably, the estimates in Study 1 appeared stronger and more robust than in Study 2. This may be a function of the estimation strategy, time frame analyzed, or the sensitivity of the instrument measuring gambling distortions. In addition, Study 1 relied on an internet sample recruit through Mechanical Turk. Although we attempted to mitigate bias where possible, it may be the case that these results are non-representative, are impacted by selection bias, and/or are impacted by professional respondent bias. Future work in other populations would help support our findings, ideally through natural experiments.

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Declarations

Conflict of interest Kahlil Philander has received research funds from the Washington State Gaming Commission, Manitoba Gambling Research Program, UNLV International Centre for Gaming Regulation, U.S.-Japan Business Council, Wynn Resorts, Board of Regents of the Nevada System of Higher Education. He has received consulting payments from British Columbia Lottery Corporation, Eilers & Krejcik Gaming, Victor Strategies, Responsible Gambling Council of Canada, the Commonwealth of The Bahamas, Hard Rock Seminole, and iDevelopment and Economic Association. He has received reimbursement for travel from the Northeast Asia Economic Association Forum, National Council for Problem Gambling, International Association of Gaming Advisors, National Centre for Responsible Gambling, North American State and Provincial Lottery Association, Evergreen Council on Problem Gambling, Global Gaming Expo Asia, and Alberta Gambling Research Institute. Dr. Gainsbury has worked on projects that have been received funding and in-kind support through her institution from Australian Research Council, NSW Office of Responsible Gambling, Svenska Spel Research Council, Responsible Wagering Australia, Australian Communication and Media Authority, Commonwealth Bank of Australia, GameCo, ClubsNSW, Crown Resorts, Wymac Gaming. Dr. Gainsbury is currently a member (2020–21) of the National Council on Problem Gambling International Advisory Board (Singapore) and receives an honorarium for this role. She is a member of the Steering Committee for Remote Gambling Research and the Independent Research Oversight Panel both run by GambleAware, which provide an honorarium for reviewer reports. Dr. Gainsbury has received honorarium and travel costs for research, presentations and advisory services from Credit Suisse, Oxford University, ClubsNSW, Clubs4Fun, Centrecare WA, Gambling Research Exchange Ontario, Crown, Department of Social Services, Community Clubs Victoria, Financial and Consumer Rights Council Victoria, Australian Communications and Media Authority, Gamble Aware, Ministry of Health, Clayton Utz, Greenslade, Generation Next, KPMG, Stibbe, QBE, Stiftelsen Nordiska Sällskapet för Upplysning om Spelberoende, Japan Medical Society for Behavioural Addiction, National Council for Problem Gambling Singapore. All professional dealings have been conducted with the aim of understanding gambling, enhancing responsible gambling and harm minimisation policies and practices as well as treatment interventions.

Ethical Approval All research has had human research committee ethics approval.

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