Gambling Fallacies: What are They and How are They Best Measured?

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Abstract

Objective: Gambling fallacies are believed to be etiologically related to the development of problem gambling. However, this evidence is tenuous due to the lack of consensus on which things constitute gambling fallacies and the adequacy of instruments that ostensibly measure them. The purpose of this paper is to comprehensively identify the main gambling fallacies and examine the reliability and validity of the instruments designed to measure them.

Methods: All known gambling fallacies and instruments measuring them were identified via a keyword search of social science, medical, and gambling-specific databases. The reliability and validity of each assessment instrument was then examined.

Results: Six primary gambling fallacies were consistently reported in the literature. Eighteen instruments were found to measure one or more of these fallacies, with 9 assessing specific fallacies and 9 intended to be comprehensive instruments. Most instruments were found to have good internal consistency as well as adequate convergent and external validity. Relatively few demonstrated test-retest reliability and/or discriminant validity. However, the main area of concern was content validity. While instruments focusing on a particular fallacy tended to have adequate content validity, this was not true of the comprehensive instruments. In addition to insufficient coverage of the fallacies, most comprehensive instruments included questions pertaining to motivations for gambling, attitudes about gambling, and/or problem gambling symptomatology (e.g. chasing losses), which likely inflates their statistical association with problem gambling. Many of these comprehensive instruments also wrongly assume that no skill is involved in any form of gambling.

Conclusion: The inadequate content validity of most comprehensive gambling fallacy instruments draws into question the strong etiological relationship gambling fallacies are presumed to have with problem gambling. This concern is compounded by the fact that all research reporting this association has been cross-sectional and correlational in nature. Re-examination of this relationship using improved instrumentation in a longitudinal context is required.

Keywords: Gambling fallacy; Cognitive error; Cognitive bias; Distortion; Superstition; Illusion of control

Introduction

A large number of general cognitive biases and heuristics are known to interfere with optimal decision-making and judgement [1-5]. Most of these biases also have the potential to directly or indirectly compromise decision making in gambling. The term 'gambling fallacies' refers to specific erroneous beliefs about how gambling works that derive from these general cognitive biases. That is also the meaning of this term in the present paper. 'Gambling fallacy' is used in preference to 'cognitive distortion' and 'cognitive bias' to make it clear that the focus is on erroneous thoughts and beliefs rather than general cognitive biases and distortions that may interfere with optimal judgement and decision-making, but do not necessarily create erroneous gambling-related beliefs.

Gambling fallacies appear to be common among gamblers [6-13], and especially common among problem gamblers [14].

Because of this consistent association there is a strong presumption that gambling fallacies are etiologically involved in the development of problem gambling [15-21]. Following on this belief, correcting erroneous gambling cognitions is central to most programs designed to prevent and/or treat problem gambling [15,22-25].

However, the presumption of an etiological relationship with problem gambling may be premature. First, all of the research documenting a relationship between problem gambling and gambling fallacies has been cross-sectional and correlational in nature. The co-occurrence of gambling fallacies and problem gambling does not establish whether gambling fallacies caused problem gambling, or whether problem gambling caused gambling fallacies, or whether they developed at the same time. Second, as noted by several authors [14], the field lacks consensus on 1) what specific things constitute gambling fallacies and 2) which instruments best assess them. As will be discussed in the present article, a comprehensive review of these two issues would suggest that the relationship between gambling fallacies and problem gambling has been artifactually inflated due to the inadequate content validity of most existing instrumentation.

What are the Specific Gambling Fallacies?

As is the case with cognitive biases more generally, there is no well agreed-upon list or categorization of gambling fallacies, although different categorizations have been proposed [15,20,26-29]. Thus, the first step was to identify all the potential gambling fallacies via a keyword search of all the social science and medical databases (e.g. PsycINFO, MEDLINE, ABI/INFORM Global, PubMed, Science Direct, etc.) through two omnibus search engines (the university library's SUMMON search engine and Google Scholar). As a significant portion of scholarly gambling research is not contained in academic journals, this search was supplemented by a keyword search of gambling-specific databases so as to better identify gambling fallacies cited in the "grey literature" (Australasian Gaming Council eLibrary, Gamblib, Problem Gambling Foundation of New Zealand eLibrary, Responsible Gambling infohub, Canadian Partnership for Responsible Gambling e-library, Alberta Gambling Research Repository). Depending on the specific database examined, the keywords and phrases used were: gambling fallacy, fallacy, cognitive distortion, cognitive bias, errors in thinking, superstition, illusion of control, hot hand.

Six distinct fallacies were repeatedly identified in the literature, with the first four being the most often cited. These four are inter-related to each other because they are generally reflective of a misunderstanding of the random and uncontrollable nature of many gambling games:

- **Hot hand fallacy:** Many gambling devices (e.g. dice, electronic gambling machines, roulette wheels, lottery and bingo ball machines) have been specifically created to produce random outcomes, with the previous outcome having no influence on future outcomes. Nonetheless, many people fail to appreciate this, erroneously believing that a winning streak on these devices portends more winning and/or that winning numbers are more likely than other numbers to appear again [30-33] Another manifestation of this fallacy is the common perception of a 'hot hand' in sporting performances, even though research shows that random chance accounts for most of these streaks [33-35].

- **Monte-carlo fallacy:** This fallacy, which is also known as the classic 'gamblers fallacy' is also related to the failure to understand the independence of random events, but results in people betting on the opposite outcome to occur, due to the erroneous belief that statistical deviations in one direction will be corrected by statistical deviations in the other direction to even things out [30,31,36]. Examples of this are the belief that an electronic gambling machine that has not paid out in some time is increasingly likely to pay out, and/or that a machine that has just paid out a large win is less likely to do so again in the near future. Another indirect manifestation of this fallacy is the belief that an orderly sequence of numbers (e.g. 1, 2, 3, 4, 5) is less likely to win the lottery compared to a non-orderly sequence (e.g. 7, 25, 2, 33, 1). The 'representativeness heuristic' [37] is the more general bias that helps create this gambling-specific fallacy.

- **Belief that luck is dispositional:** This is the erroneous belief that randomly determined events consistently favour or disfavour some things over others [12,13,38-41]. This could be certain people, time periods, colours (e.g. red), numbers (e.g. 7, 9 versus 4, 13), etc.

- **Illusion of Control:** It is a common tendency to believe that one's actions can influence random events [42]. In gambling, this erroneous belief takes the form of believing that choosing one's own lottery numbers [43] or roulette numbers [44] is preferable to having them randomly selected, or that certain betting techniques or strategies can better assure success in games with random outcomes [45-49]. Superstitious conditioning is one of the processes contributing to this illusion of control. A basic principle of operant and classical conditioning is that the context and actions associated with a rewarding event become associated with the reward, even though very few of these actions and elements have any direct causal relationship. People then commonly re-invoke these extraneous elements and/or actions the next time they confront this situation in the belief it may facilitate a rewarding outcome [50,51].

Two other specific gambling-related errors in thinking, while being related to the above fallacies, have more to do with failure to take mathematical and statistical principles into account. The large majority of commercial gambling offerings are provided in a way that ensures high variability of short-term outcomes, but long-term statistical advantage to the gambling provider [52]. Failure to be aware of these mathematical principles or disavowal of these facts is a common gambling-specific error in thinking [53-56]. Two specific aspects of this deficient statistical knowledge particularly relevant to gambling are as follows:

- **Insensitivity to sample size:** People commonly fail to realize that deviations from expected probabilities are common with small samples, but increasingly uncommon with large samples [57]. So, for example, many people will erroneously report that a roulette wheel that has produced 80% reds is just as likely to have occurred with 5 spins as 500 spins. The consequence of this failure to take sample size into account is the person failing to understand that winning is common with small samples but increasingly rare with extended play.

- **Base rate neglect:** People often ignore general statistical probabilities in judging how frequently an outcome occurs [58]. Rather, they often estimate frequency by how available instances of the event are in their memory [59]. One gambling-related manifestation of this bias is the belief that participating in commercial forms of gambling is a good way of making money. Another example is the perception that winning the lottery is more likely than it actually is due to the number of people a person is aware of that have won the lottery over the years.

How are Gambling Fallacies Best Measured?

A good assessment instrument needs to be both reliable and valid. What exactly constitutes reliability and validity in the context of a gambling fallacies instrument is the subject of the present section. The main types of reliability are test-retest, parallel forms, inter-rater, and internal consistency. The applicability of each of these to a gambling fallacies assessment instrument is explored below:

- **Test-retest:** Stable answers to erroneous beliefs about gambling over a short period of time is a good index of reliability, as it provides reassurance that the questions are clear and that the answers are definitive and speak to a belief that has some stability. Extremely short periods of time (1 hour – few days) are not optimal, as memory for previous responses may shape current responding. Similarly, very long periods of time (e.g. one year) are not optimal as these beliefs should be malleable to some extent. Thus, a period of time between a week and a month would theoretically seem to be an optimal time frame to establish test-retest reliability of gambling fallacies.

- **Parallel forms:** If different versions of a gambling fallacies instrument exist, then the results of the two instruments should be

strongly correlated with each other. However, as it is not essential that parallel forms should exist, this type of reliability is also not essential.

- **Inter-rater:** In general, third party assessment of gambling fallacies would appear to be a less direct and efficient way of assessing fallacies compared to a set of questions the person answers themselves. Hence, this type of reliability would also not appear to be needed.

- **Internal consistency:** Adequate levels of internal consistency are desirable for each factor underlying a gambling fallacies instrument. As will be discussed in greater depth later, the number of factors underlying gambling fallacies is somewhat unclear as most existing comprehensive instruments have included general non-fallacious biases, attitudes, and/or behaviours in the instruments, which could account for multiple factors being identified. While a few studies have found just one gambling fallacies factor [21,60,61] it has been more common to find multiple factors. More specifically, two factors [26,28,62-65] and five factors[66-68]. Thus, it is would seem that high levels of overall internal consistency is likely not desirable for a gambling fallacies instrument, unless measured for each factor and/or using a hierarchical measure of consistency (e.g. coefficient omega).

There are several different ways of dimensionalizing validity and several different terms used to describe similar types. The main dimensions used in the present paper are construct and external validity, with content, concurrent, convergent, and discriminant being subtypes of construct validity. A case will be made that all of these types of validity need to be demonstrated in a gambling fallacies instrument.

Content: Content validity for a comprehensive gambling fallacies instrument requires comprehensive and even coverage of the previously identified fallacies. Instruments that just focus on one fallacy (e.g. superstitions [89]; luck [38,40,41,69,70]; illusion of control [71]) do not provide adequate coverage. Similarly, instruments that include questions on general attitudes or motivations (e.g. gambling to win money), biases (e.g. choosing to focus more on wins than losses), and/or behaviour (e.g. always wearing red while gambling; chasing losses) are not measuring fallacies in the absence of a direct attribution to a false belief (e.g. playing electronic gambling machines because it is a good way of making money; wearing red because it improves luck). Instruments or questions that wrongly presume that no skill is involved in any form of gambling and/or fail to specify that the questions only pertain to pure chance games also lack content validity (e.g. Gambling Cognitions Inventory; [28]) (as an element of skill is involved in sports betting, horse race handicapping, and certain card games such as poker [72]). Finally, instruments that assess generic errors in thinking or fallacious beliefs without specific reference to a gambling situation also do not have sufficient content validity for a gambling fallacies instrument (e.g. Irrational Belief Measure [73]; Irrational Belief Scale [74]; Paranormal Belief Scale [75]).

- **Concurrent:** This refers to whether the test is correlated with another measure of the same construct that has been previously validated. As no prior instruments have received unambiguous validation, this type of validity is not examined here.

- **Convergent:** This refers to whether the test is correlated with similar constructs, beliefs, and behaviour theoretically reflective of the construct (either concurrently, or in the future). It has been common to show convergent validity of a gambling fallacies instrument by its current or future correlation with gambling and/or problem gambling. There is some logic to this, as it reasonable to expect that erroneous beliefs about the potential for winning should contribute to gambling involvement and over involvement. However, the extent to which these instruments have also included non-fallacious motivations or attitudes correlated with gambling involvement and/or signs of problem gambling (as they often have) are the extent to which these correlations will be artificially inflated. It needs also to be recognized that gambling fallacies are also very common in the general population, most of who gamble very little or not at all [76]. Hence, the relationship with gambling and/or problem gambling will always be relatively weak. There are other constructs that bear a much stronger theoretical connection to gambling fallacies and should be used to demonstrate convergent validity. These include: general errors in thinking, paranormal beliefs, lower educational attainment, lower mathematical skill or training, and lower intelligence.

- **Discriminant:** A gambling fallacies instrument needs not only to show association with related constructs, but lower and/or lack of association with theoretically unrelated behaviour, concepts, or measures (e.g. marital satisfaction, perceived stress, etc.).

- **External:** External validity of a gambling fallacies instrument is demonstrated by the generalizability of its scores across gambling situations as well as generalizability of its application across different age groups, educational levels, clinical and non-clinical populations, countries, and cultures.

What is the Reliability and Validity of Existing Gambling Fallacy Instruments?

The same search of the literature described earlier identified 18 instruments intended to either comprehensively assess gambling fallacies, a subset of gambling fallacies, a specific fallacy relevant to gambling (e.g. belief in luck), and/or to assess gambling fallacies as part of a broader gambling-related instrument. A brief description of each of these instruments as a candidate for a comprehensive, reliable, and valid gambling fallacies instrument is provided below. They are presented in order of their publication date.

- Belief in Good Luck Scale (BIGL) [38]. The BIGL is a 12 item Likert scale assessment (strongly agree=1 to strongly disagree=6) of the extent to which individuals believe in personal good luck. Studies were conducted with Ontario Science Centre visitors (Study 1: n=231), Toronto university students (Study 2; n=1453), and students at New York University (Study 3; n=494). Factor analysis found a single factor underlying the instrument. Internal consistency was good (Cronbach α ranging from 0.78 to 0.85 depending on the study). Test-retest reliability over a period of one to two months was adequate (r=0.63). Convergent validity was established by a significant correlation with locus of control and discriminant validity was established by BIGL's lack of correlation with general optimism, academic pessimism, self-esteem, desire for control, and achievement motivation. Asian-Americans were more likely to believe in personal luck compared to non-Asians. In a subsequent study, Chiu and Storm [77] found problem gamblers to have higher scores on the BIGL compared to other types of gamblers. In another study, Prendergast and Thompson [78] found that belief in being personally lucky was associated with selecting a lucky draw over other sales promotions options. These investigators also found the scale to be composed of two factors: a general belief in luck and a belief in being personally lucky.

- Gambling Attitudes and Beliefs Survey – GABS [60]. The GABS is a 35 item Likert scale assessment (1=strongly agree to 4=strongly disagree) of gambling-related cognitions, behaviours, and attitudes. While three fallacies are included in the measure (illusion of control, luck, and the Monte Carlo fallacy), the GABS does not comprehensively evaluate all gambling fallacies, nor does it differentiate susceptibility to fallacies from motivation for gambling and problem gambling behaviours (i.e., it includes questions on whether the person gambles to feel excitement, to improve mood, as a means to escape everyday problems, and whether person loses track of time while gambling). Factor analysis of this measure indicates a single construct, aptly named "affinity towards gambling". In their pilot sample of 625 U.S. students in introductory psychology university classes and a treatment seeking sample of 86, Cronbach alpha was excellent (α=0.90 and 0.93, respectively). GABS scores were significantly correlated with gambling engagement and problem gambling scores. Subsequent studies using the GABS to compare treatment seeking samples to university samples in the United States have found it to discriminate between the groups and to be correlated with gambling involvement [79,80].

- Belief about Control Over Gambling – BAC [71]. Rather than assessing the full scope of gambling fallacies, the 19 item Likert scale BAC (5=strongly agree to 1=strongly disagree) was developed to evaluate perceived control over gambling in a large sample of Australian secondary school (n=757) and first year post-secondary students (n=250). Factor analysis identified five factors. The Cronbach alpha of all factors except the 'cynicism about winning' factor was good (at or above 0.80). The 'illusion of control' factor was found to significantly predict gambling frequency, but was not a significant predictor of problem gambling.

- Questionnaire of Attitudes and Beliefs about Gambling – QABQ [62]. The QABQ is a 16 item Likert scale questionnaire (1=totally disagree to 4=totally agree) that evaluates knowledge about gambling (i.e., "the lottery is a gambling game"), and beliefs about gambling (i.e., "betting money can become a problem like alcoholism and drug addiction"). A subset of the seven items assessing beliefs about gambling evaluates fallacious thought (i.e., "I don't have more chances to win at the lottery if I choose the numbers myself"). The QABC was not intended to be a comprehensive evaluation of gambling-related erroneous cognitions. Rather, it was designed as a pre- post-test measure for an intervention designed to reduce the incidence of problem gambling in 424 Canadian middle-school aged children. Factor analysis confirmed two distinct factors, with a low Cronbach alpha for the misconception factor (0.58) and a good Cronbach alpha (0.74) for the gambling knowledge factor. This questionnaire has been translated into Italian [81], and similarly used to evaluate the efficacy of a problem gambling intervention program among Italian high school students [82].

- Gambling Belief Questionnaire - GBQ [64]. The 21 item Likert scale GBQ (1=strongly agree to 7=strongly disagree) evaluates the full range of gambling fallacies. However, it also includes questions about problem gambling behaviours (e.g. chasing losses, borrowing money for gambling, lying to loved ones) as well as other extraneous items (e.g. valuation of the excitement of gambling engagement). The GBQ also erroneously considers all references to skill at gambling to be fallacious (e.g. "gambling is more than just luck"; "gambling wins provide evidence of skill and knowledge"). Statistical analysis has identified two factors, described as: luck/perseverance and illusion of control. The Cronbach alpha of each factor and the full scale are good to excellent (0.90, 0.84, and 0.92, respectively). The two-week test-retest reliability of each factor and the total questionnaire are also good (r=0.71, 0.77, and 0.77). In a U.S. sample comprised of both undergraduates (n=200) and community members (n=203), problem gamblers scored significantly higher than non-problem gamblers (which is to be expected considering the inclusion of problem gambling behaviours). The full GBQ score and the luck/perseverance scores were also significantly related to self-reported gambling session lengths (r=0.43, and 0.48).

- Gambling Fallacies Measure – GFM [65]. The GFM (Appendix A) consists of 10 multiple-choice items, each with only one correct answer. Higher scores reflect greater resistance to gambling fallacies. The GFM comprehensively assesses all of the identified gambling fallacies: hot hand fallacy (questions 2, 4, 10); Monte-Carlo fallacy (questions 1, 2, 4, 10); belief that luck is dispositional (questions 3, 4); illusion of control (questions 5, 8, 9); insensitivity to sample size (question 6); and base rate neglect (question 7). Unlike most instruments, the GFM does not include any non-fallacious motivations, attitudes, biases or problem gambling behaviours. Factor analysis across multiple datasets has found a two factor solution to be most consistent: a failure to understand the random and uncontrollable nature of most gambling games (questions 1, 2, 3, 4, 5, 8, 9, 10) and a failure to take statistical probabilities into account (questions 6, 7). The hierarchical coefficient omega [83] shows adequate (0.61) internal consistency. The overall one-month test-retest reliability of the instrument is good (0.70). The measure has been successfully employed in multiple samples comprising over 17,000 people, with these samples spanning ages 13-89, dozens of different countries, and including over 1,000 problem gamblers [76,84-87]. Depending on the dataset, GFM scores have been found to be consistently and significantly associated with intelligence, educational attainment, paranormal beliefs, and gambling 'to win money' as a primary motivation. The GFM has also usually (but not always) been significantly associated with problem gambling (r=-0.03 to -0.16) and various measures of gambling involvement (r=0.06 to -0.12). Discriminant validity has been demonstrated with findings of near zero associations between GFM scores and marital satisfaction, general life happiness, and past year perceived stress.

- Gambling Belief Questionnaire- GBQ2 [17]. This questionnaire contains 56 Likert scale items (0=not at all to 4=very much) intended to evaluate 12 facets of gambling-related thought. Seven of the 12 facets evaluate non-fallacious biases and problem gambling behaviours. Furthermore, all references to skill at gambling are erroneously classified as fallacious. The Cronbach alpha of the full scale is extremely high (0.97), which is related to the very large number of questions in the questionnaire. No internal consistencies were reported for the 12 facets. Participants included in the validation of the GBQ2 included Australian problem gambling treatment seekers (n=56) and a group of social gamblers (n=52). Significantly higher scores were obtained by the treatment seeking sample as compared to the social gambling sample on all facets except "denial" (a facet evaluating whether the person acknowledges gambling related problems). Two subsequent studies in Scotland [66,88] have used a shortened 48 item variant of this measure (GBQ2). Moodie [66] found no significant differences on GBQ2 scores between problem and social gamblers. However, Moodie [88] did find significant differences between problem video lottery terminal gamblers and non-problem

gamblers. The GBQ2 was also found to correlate with level of gambling involvement. Factor analysis by Moodie [66] found five factors in a 24 item version of the scale that did not support the theoretically driven facets identified by the original authors.

- Superstitious Beliefs in Gambling – SBG [89]. The SBG was not developed to assess the full scope of gambling fallacies. Rather, the eight-item Likert scale assessment (0=not at all to 4=very much) was developed just to evaluate superstitious beliefs. There is no information on the reliability of this instrument. Concurrent validity was demonstrated by the significant positive relationships between the SBG and scores on the South Oaks Gambling Screen (SOGS) [90] as well as typical time spent in gambling sessions. It is possible that these associations were artificially inflated as more than half this Australian sample were treatment seeking problem gamblers (n=56 treatment seeking versus n=45 non-problem gamblers).

- The Informational Bias Scale – IBS [61,63]. The IBS is a 25 item Likert scale instrument (1=don't agree at all to 7=strongly agree) developed to evaluate irrational beliefs in video lottery terminal players. The IBS does not evaluate the full scope of gambling fallacies. It also contains items that evaluate problem gambling behaviours (i.e., chasing losses), as well as non-fallacious biases (e.g. choosing to focus on wins rather than losses, preferring to play on specific electronic gambling machines). Principal component analysis on a sample of 96 predominantly Canadian problem gamblers identified a single component. In a subsequent study (2004) with a larger and non-problem gambling Canadian sample (n=228), two components were identified: the Monte Carlo fallacy and the tendency to make erroneous inferences concerning VLT outcomes. The Cronbach alpha of each component was good to excellent (0.81 and 0.90). Education regarding how video lottery terminals work (Jefferson et al. [63], experiment 2) was found to significantly reduce IBS scores. IBS scores were found to account for 10% of the variance in SOGS scores, and 5% of the variance in DSM-IV pathological gambling lifetime scores.

- Gambling Related Cognitions Scale – GRCS [68]. The GRCS is a 23 item Likert scale instrument (1=strongly disagree to 7=strongly agree) comprised of five factor analysis derived subscales: interpretive bias, illusion of control, predictive control, gambling-related expectancies, and perceived inability to stop gambling. The GRCS does not evaluate the full scope of gambling fallacies and only the illusion of control subscale evaluates purely fallacious gambling-related thought. The other subscales include several extraneous items (e.g. my desire to gamble is overpowering; gambling makes me happier; having a gamble helps reduce tension and stress; I prefer to focus on wins). High internal consistencies are reported for the total scale (Cronbach alpha=0.93) and each of the factors (range: 0.77-0.91). Initial validation of this measure was undertaken using a large (n=968) demographically diverse Australian community sample. Additional studies of the GRCS have led to creation and validation of Italian [91], Turkish [92], and Chinese [67] versions of the measure (with the original factor structure supported in these subsequent studies). Higher GRCS scores have been found to be associated with problem gambling [93-95], the increased likelihood of relapse in problem gambling [96], neuroticism [91], and "proneness to delusion" [97]. The initial validation report indicated significant gender differences on GRCS total scores and all subscales except illusion of control [68]. Subsequent studies have not consistently replicated this finding [93,95].

- Perceived Personal Luck Scale - PPLS [41]. The PPLS is the 10 luck/perseverance Likert scale items from Steenbergh et al. [64] GBQ (1=strongly agree to 5=strongly agree). As mentioned earlier, these items erroneously classify all references to skill in gambling as fallacious. As was the case during the original measure, the Cronbach alpha associated with this measure is good (0.88). In a sample drawn from a Canadian university, the PPLS was used to evaluate differences between problem gamblers with an affinity for pure chance games (n=19) as compared to problem gamblers who prefer mixed chance/skill games (n=19). Between group differences were detected, with pure chance game enthusiasts reporting lower belief in personal luck.

- Drake's Belief about Chance Inventory – DBC [98]. The 22 item Likert scale DBC (1=strongly disagree to 5=strongly agree) measures two dimensions derived by principal component analysis: superstition and illusion of control. This measure was not designed to evaluate the full scope of gambling fallacies. It includes questions about non-gambling related paranormal beliefs (e.g. belief in astrology, using lucky pen/pencil while taking tests, general superstitious beliefs, etc.).Wood and Clapham [98] report good to excellent Cronbach alphas for each dimension (superstition=0.85, illusion of control=0.88) as well as for the whole scale (0.91). DBC scores were shown to be significantly positively associated with gambling frequency in a U.S. sample of treatment seekers (n=68) and members of the general public (n=239).

- Andre [99] developed an unnamed 18 item Likert scale test (1=strongly agree to 5=strongly disagree) of fortune, luck, and opportunity in a sample of 195 French university students. Principal component analysis identified four components: bad fortune, good fortune, luck, and opportunity. The questions on 'opportunity' (e.g. "I am able to seize the opportunity") are not directly relevant to gambling. Cronbach alphas for the four components ranged from 0.70 to 0.88. Luck was significantly positively correlated with self-esteem and achievement motivation and negatively correlated with anxiety. Good fortune was positively correlated with self-esteem. Bad fortune was positively correlated with anxiety and negatively correlated with self-esteem. Opportunity was positively correlated with self-esteem and achievement motivation and negatively correlated with anxiety.

- Beliefs around Luck Scale – BALS [69]. This 22 item Likert scale test is an expansion of the Belief in Good Luck Scale (BIGL) [38] to include belief in bad luck (strongly agree=1 to strongly disagree=6). Maltby et al. [69] found four components underlying this revised scale (belief in luck, rejection of luck, being lucky, and being unlucky) across two samples derived from workplaces and community groups in the United Kingdom (n=250; n=145). Each of the components had adequate to good internal consistency (α ranging from 0.69 to 0.89). One month test-retest reliability of the four components was low, ranging from 0.48 to 0.58. The subscales showed the expected associations with measures of personality and subjective well-being (e.g. belief in being unlucky being associated with neuroticism).

- Gambling Related Cognitive Distortions – GRCD [21]. The GRCD is comprised of 12 Likert scale questions (1=never to 5=always). Not all gambling fallacies are addressed within the GRCD. Furthermore, half of the GRCD items assess non-gambling specific concepts (i.e., "you identified a pattern in the way outcomes or events were happening", "you have had a hunch or a gut feeling about a future event, or thought you could predict the outcome of a

future event") and/or non-fallacious experiences (i.e., "you have had a big win on a previous bet"; "you have had a long shot opportunity"). Factor analysis conducted on data collected from 790 U.S. male twins found a single factor with a Cronbach alpha of 0.89. A significant association was observed between scores on the GRCD and problem gambling scores.

- Personal Luck Usage Scale – PLUS [40]. The PLUS is a one dimensional eight-item scale derived and subsequently confirmed among university-aged gamblers in Canada (n=347 in Study 1 and n=361 in Study 2). Importantly, the PLUS was distinguishable from a general belief in luck (Study 2). In Study 3 (n=60), a behavioural consequence of belief in personal luck was assessed among a community sample of gamblers. PLUS scores were found to be positively associated with the average amount of money spent in a gambling session.

- Belief in Luck and Luckiness Scale - BLLS [70]. The BLLS is a 16 item Likert scale (1=strongly disagree to 5=strongly agree) list of questions about luck. A series of studies (total n=1202) using British university employees as well as university students in Britain, Japan, and Hong Kong found two dimensions underlying the scale: 'belief in luck', and 'luckiness'. The 2 month test-retest reliability was 0.56 for the Belief in Luck dimension and 0.75 for Personal Luckiness. Belief in luck correlated positively with locus of control. Personal luckiness correlated positively with extraversion, conscientiousness, life satisfaction, positive affect, and negatively with neuroticism, locus of control, and negative affect.

- Gambling Cognitions Inventory – GCI [28]. The GCI is a 33 item Likert scale (0=strongly disagree to 3=strongly agree) list of gambling-related biases, behaviours, and fallacies. The CGI does evaluate the full range of gambling fallacies. However, it also includes problem gambling behaviours (e.g. chasing losses) as well as predispositions that are not necessarily fallacious (e.g. tendency to focus on wins rather than losses). Nine of the 33 CGI items also erroneously classify endorsement of perceived skill in gambling as fallacious (without contextualizing the questions as referring to just pure chance games). Two factors underlie the CGI: attitude/skill and luck/chance. The GCI was validated by re-analysis of four Canadian problem and pathological gambling sample datasets (n=710). Reported Cronbach alpha for the entire CGI ranges from 0.91-0.95, and between 0.77 to 0.92 for the subscales. Significant positive associations exist between GCI scores and scores on the

Magical Ideation Scale [100], the Measure of Irrational Belief [74], and problem gambling as measured by the NODS [101] and/or SOGS [90]. Discriminant validity was established by its low association with the Perceived Stress Scale [102], and the Beck Depression Inventory [103]. No significant gender differences on subscale or total CGI scores have been found.

Summary, Conclusion, and Future Directions

Six primary gambling fallacies were consistently reported in the literature. Eighteen instruments were found to measure one or more of these fallacies, with 9 assessing specific fallacies and 9 intended to be comprehensive instruments. A summary of the reliability and validity of each of these instruments for the assessment of gambling fallacies is presented in Table 1. Correlation coefficients and/or measures of internal consistency of 0.70 or higher (good to excellent) are identified with two asterisks, values between 0.60 and 0.69 (adequate) are identified with a single asterisk, and values below 0.60 and/or that are not reported have an empty cell.

As can be seen, most of these instruments have good internal consistency, as well as adequate convergent and external validity. Relatively few instruments have demonstrated test-retest reliability and/or discriminant validity.

However, the main area of concern is content validity. While instruments focusing on a particular aspect of gambling fallacies (i.e., luck, control, superstitions) tend to have adequate content validity, this is not true for most instruments intended to more comprehensively capture gambling fallacies. Rather, almost all comprehensive instruments have one of more of the following problems: a) they do not assess all the known fallacies; b) they erroneously identify any belief in gambling-related skill to be fallacious; c) they include the assessment of non-fallacious attitudes (e.g. enjoyment of gambling), motivations (e.g. gambling to improve mood), biases (e.g. choosing to focus on wins rather than losses), or behaviours (e.g. chasing losses). The GFM appears to be the only comprehensive instrument that does not have these problems. To be fair, some of these comprehensive instruments were likely designed to assess more general motivations, behaviours, and biases rather than strictly erroneous beliefs about gambling. While this may be true, it is also true that understanding the relationship between gambling and gambling-related errors in thinking requires an unambiguous measure of these errors in thinking.

Author	Measure	Focus	Internal Consistency	Test Re-Test Reliability	Content Validity	Convergent Validity	Discriminant Validity	External Validity
Darke and Freedman [38]	BIGL	Good luck	**	*	*	*	*	**
Breen and Zuckerman [60]	GABS	Comprehensive	**				*		*
Moore and Ohtsuka [71]	BAC	Control over Gambling	**		**	*		
Ferland et al. [62]	QABQ	Comprehensive	*			*		*
Steenbergh et al. [64]	GBQ	Comprehensive	**	**		*		*
Williams [65]	GFM	Comprehensive	*	**	**	*	*	**
Joukhador et al.[17]	GBQ2	Comprehensive				*		*
Joukhador et al. [89]	SBG	Superstitions			*	*		

Jefferson and Nicki [63]	IBS	Comprehensive	**			*		*
Raylu and Oei [68]	GRCS	Comprehensive	**			*		**
Wohl et al. [41]	PPLS	Personal luck	**			*		
Wood and Clapham [98]	DBC	Chance	**			*		*
Andre [99]	--	Fortune, Luck, Opportunity	**		*	*	*	
Maltby et al. [69]	BALS	Luck	**		**	*	*	
Xian et al. [21]	GRCD	Comprehensive	**			*		
Wohl et al. [40]	PLUS	Personal luck			**	*		
Thompson and Prendergast [70]	BLLS	Luck		*	**	*	*	**
McInnes et al. [28]	GCI	Comprehensive	**			*	*	*

Table 1: Evaluation of Measures of Gambling Fallacies; Blank cell=inadequate or not reported, *=adequate (0.60-0.69) **=good or excellent (0.70 and higher).

The inclusion of items measuring problem gambling tendencies in most of these comprehensive instruments almost certainly inflates their statistical association with problem gambling and draws into question the previously established "robust association" between gambling fallacies and problem gambling reported in a recent meta-analysis of this relationship by Goodie and Fortune [14]. This, in turn, casts some doubt on the cognitive model of problem gambling which posits that erroneous gambling-related cognitions are key in the development and maintenance of problem gambling [15,22-25].

Reassuringly, the GFM, a purer measure of fallacies, has still typically obtained significant relationships with both gambling and problem gambling in diverse samples. However, the magnitude of these correlations has been very low and sometime non-significant (-0.03-0.16).

Furthermore, it is important to remember that this research, indeed, all research documenting a relationship between problem gambling and gambling fallacies has been cross-sectional and correlational in nature. The co-occurrence of gambling fallacies and problem gambling does not establish whether gambling fallacies caused problem gambling, or whether problem gambling caused gambling fallacies, or whether they developed at the same time. The only way of disentangling this relationship is through longitudinal research. However, to date there has never been a published longitudinal study showing that high levels of gambling fallacies creates risk for subsequent development of problem gambling. Re-examination of this relationship using improved instrumentation in a longitudinal context is required.

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