Gambling Behaviour and Understanding of Probability Concepts Among University Students

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A questionnaire was developed to examine understanding of chance and probability concepts. Measures were taken of gambling behaviour, mathematics skills and understanding of a range of probability concepts. Correlations were calculated to examine relationships between gambling behaviour and mathematical knowledge. Responses to some questions will be described. Key misunderstandings in pure chance gambling, e.g. electronic gaming machines, include a lack of understanding of independence, randomness, and short and long run expectations.

Excessive gambling losses cause major personal and social problems in communities in Victoria (Roy Morgan Research 2000). Indeed, it is claimed that Australia has the highest rate of problem gamblers in the world (Costello & Millar 2000). While the behaviour of gamblers has been analysed, including detailed description of erroneous thinking (Rogers 1998), this has largely been done without discussion of understanding of the mathematical facts involved (Smith 2001).

The underlying hypotheses of this work were that gamblers' relevant mathematical understandings are minimal or mistaken, and that a well designed program of education in this area will lead to a reduction in gambling behaviour in some people. Prior to developing a teaching program for at-risk gamblers it was desirable to establish whether or not there is a relationship between probabilistic understandings and chronic gambling.

Literature Review

Until recently, academic description of gambling behaviour has been mostly within the field of psychology, where even cognitive approaches have paid little attention to mathematical knowledge. Relevant recent studies on aspects of gambling behaviour include a study (Ladouceur 2001) in which erroneous vocalisations when gambling, were compared between groups with high mathematical background (actuarial, mathematics and statistics students) and groups with less maths knowledge (humanities students). It was found the high maths achievers exhibited as many erroneous attitudes *when gambling,* as did the non-maths group. Also useful is a study by Macdonald, Turner et al. (2001), who used a questionnaire to assess understanding of randomness. Suitable questions from that survey have been included among the probability questions in this study.

Typically, research has not sought explanations for problem gambling, nor treatment, in terms of mathematical understandings. A substantial study in Texas (Wallisch 1996) typifies the non-mathematical perspectives that have been brought to the gambling problem. Within a cognitive approach, Rogers (1998) outlines the main theories of gambling as related to non-pathological lottery play. Biases and irrational thinking patterns include misunderstanding of lottery odds, a susceptibility to the gambler's fallacy and cognitive entrapment, a belief in hot and cold numbers, unrealistic optimism, a belief in personal luck, superstitious thinking, the illusion of control, the erroneous perception of near misses, a susceptibility to prize size and rollover effects, the framing of gambling outcomes and finally, the influence of social factors on lottery play.

Error analysis of the above fallacies suggests that clear understanding of a limited number of key mathematical concepts cuts through them all. These concepts include fair game, net loss game, average expected result or long run effect of house margin, effect of the law of large numbers on the average result, randomness and independence.

Irrational control beliefs are strongly associated with problem gambling (Langer 1975). Griffiths (1999:443) noted that "there is plenty of evidence to suggest that a gambler's ignorance about probability or situational clues may encourage gamblers to think they have some influence over mainly 'chance-determined' activities."

Parallel to the work conducted primarily in the field of psychology, there has been research in mathematics education on both teaching, and learner (mis)understanding, of relevant probabilistic concepts. Efforts have been made within educational discourse to describe student learning across a number of relevant concepts. The radical constructivist perspective suggests individuals' understandings are built from their unique webs of prior concepts and their current subjective experience and therefore are idiosyncratic (Keeler 1997). Peard (1991) has examined four common types of misconceptions. These are the misuse of 'availability', of 'representativeness', of 'intuition', and failure to account for the base-rate.

Watson and colleagues (1994) have looked into various aspects of students' development of concepts of chance, luck, variation, and statistical understanding. Tarr and Jones (1997) have formulated a framework for assessing students' thinking on conditional probability and independence.

There has also been a considerable amount of research into adults' subjective perceptions of randomness (see Falk and Konold, 1992, for a survey). Systematic biases have consistently been found. People tend to reject sequences with long runs of the same result (such as a long sequence of heads) as not being random, and they consider sequences with an excess of alternation of different results to be random. In the case of two-dimensional tasks, clusters of points seem to prevent a distribution from being perceived as random (Batanero and Serrano 1999).

Mathematics education may be ineffective in changing gambling behaviour. Batanero and Serrano (1999) suggest independence of events is not an intuitive idea and that students continue to experience difficulties with the idea of independence even after instruction. Gal and Garfield (1997:13) warn that "many students have misconceptions or intuitive beliefs that are not being changed during instruction" and "there has been almost no research on the development and evaluation of instructional programs in probability".

Correlations have been found between predictors of problem gambling and various social and personal phenomena, such as control beliefs, risk taking, perceived social norms, gender, and leisure preferences (Moore and Ohtsuka 2000). This study seeks to extend that research into the area of mathematical understandings, principally on the ground that many gambling games, including those currently generating most social problems, are fully mathematically analysable events. In understanding their outcomes there is nothing more to them than their mathematical structure. To borrow from Galileo: Gambling "cannot be understood unless one first learns to comprehend the language … in which it is composed. It is written in the language of mathematics…"(Crosby 1997).

Methods

This research examined relationships between understanding of mathematics, especially probability, and the propensity for problem gambling, in a university sample. It was predicted that measures of probabilistic understanding would correlate negatively with measures of problem gambling.

A questionnaire was administered, taking about an hour to complete. Subsections were designed to measure each subject's gambling frequency, problem gambling, probabilistic understandings, and general mathematical skills. Demographic data were also collected.

Gambling: Two separate measures were applied. A measure of gambling frequency was developed from previous studies (Moore and Ohtsuka 2000). Respondents were asked to rate their level of participation in 12 different types of gambling, and any other. These were Cards, Horse/Dog racing, Sports, Lotteries, Scratch tickets, Casino gaming, Casino pokies, Hotel pokies, Sports club pokies, Bingo, Pool, and Share speculation. A gambling frequency scale was produced from the responses. For the frequency measure the rating scale for each type of gambling ranged from 0 = never participated, through 1 = once a year, 2 = more than once/year, less than once/month, 3 = more than once/month, less than once/week, to 4 = once a week or more. The possible range of scores was 0 – 56, with high scores representing higher frequencies of gambling.

The Canadian Problem Gambling Index (Ferris and Wynne 2001), developed over three years, was also used. Verified against both the South Oaks Gambling Screen (Lesieur and Blume 1987) and the DSM-IV criteria for pathological gambling (American Psychiatric Association 1998), the CPGI includes nine items that can be scored to produce a prevalence rate for problem gambling, with scores between 0 and 27. It is used widely in gambling prevalence studies.

Probability Knowledge: Fischbein and Schnarch (1997) developed a questionnaire using seven probability problems each indicative of a probabilistic misconception. Versions of those questions were combined with several probability questions equivalent to those for which normed results are available, such as those used in the Progressive Achievement Tests in Mathematics (PATMaths-R) (Australian Council for Educational Research (ACER), 1997). Additional questions were developed to address other probability concepts. The 37 likert, 21 multiple choice, and four open questions were grouped to assess performance in relation to particular probability knowledge and established fallacies. Fifty-eight questions were summed to generate a score for Probability Knowledge

General Mathematics Achievement: A moderated test on mathematics achievement provided by ACER was used. This is the general Mathematics Competency Test (MCT), (Vernon, Miller et al. 1996). The scoring schema was amended to include half-marks increasing the sensitivity of the score, consistent with mathematics assessment practices. The 46 questions gave a total possible score of 92.

Data Analyses

Descriptive statistics were used to analyse the spread of results on the various measures. The favoured analysis was calculation of Pearson's **r** between each of the measures of gambling behaviour and the outcomes on each of the mathematics knowledge indicators. As the measures of gambling behaviour produced results skewed heavily toward no gambling, and tapering off at high levels, it was appropriate to transform these variables, before calculating correlations even though Pearson's r is a robust test at this sample size. A logarithmic transformation was used.

Results and Discussion

The study sample comprised 143 participants at a university in the western suburbs of Melbourne. Three-quarters were first year students (with a further 11% in a preliminary year). They were drawn from the university's faculties and its division of Technical and Further Education. Most were women (64%), and 29% were Psychology students, with a further 19% Arts students. They were of various social backgrounds; 17 different languages being spoken at home, located in over 80 Victorian postcodes. They were selected in classroom groups, and the survey completed in the classroom, during or after formal class time. Participation was voluntary. Many prior studies of gambling behaviour have used school and university student samples (Moore and Ohtsuka 2000).

Eight per cent had never gambled. Thirty-three percent had not played pokies, and five percent (seven) scored as problem gamblers on the measure used (see Tables 1 & 2).

Table 1
Canadian Problem Gambling Index (CPGI)

	Non Gamblers	No Problems	Low risk	Moderate risk	Problem Gambling
Score	0	0	1 - 2	3 - 7	8 - 27
Frequency	23	64	31	18	7
Percent	16.1%	44.7%	21.7 %	12.6 %	4.9 %

The CPGI scores ranged from 0 to 19, with a mean of 1.36 (SD = 2.76). This gave an hyperbolic distribution, decidedly non-normal. Numbers of respondents rapidly decreased with increasing CPGI score. Approximately five percent of respondents being problem gamblers was consistent with previous studies, which produced results in the range two to six percent (Ferris & Wynne, 2001). People who gambled only once or twice a year were included as non-gamblers given the social difficulty in Australia of avoiding participating a raffle or a Melbourne Cup sweep.

Table 2
Gambling Frequency

Score	0	1-2	3-5	6-8	9-11	12-14	15-17	18-20	21-23	24-26	27-29
No.	11	12	32	37	22	13	5	5	4	0	2

%	7.7	8.4	22.4	25.9	13.4	9.1	3.5	3.5	2.8	0	1.4

No type of gambling was very common, but many types of gambling were engaged in moderately, a few times a year. Two–thirds of respondents had tried scratch tickets, which was the most widespread form of gambling, while sports betting was the form of gambling that had most participants (seven) on a more than weekly basis. The gambling frequency scores ranged from 0 to 29, with a mean score of 7.66 (SD = 5.76). These results were similar to those reported by Moore and Ohtsuka (2000) in a study of secondary students.

Table 3
Mathematics Skills (MCT)

Score	< 25	25-30	36-40	41-50	53-60	61-70	71-80	81-90
No.	3	3	4	20	16	36	31	29
%	2.1	2.1	2.8	14.0	11.2	25.2	22.4	21.3

Particularly low scores on the MCT by a few respondents indicate that the test was not fully attempted by them, but the incomplete attempts have not been excluded from the analysis. Results ranged from one question correct to all but one, with a mean score of 65.4 (SD = 16.9).

Table 4
Probability Score

Score	<43	43-9	50-4	55-9	60-4	65-9	70-4	75-9	80-4	85-9	90-4	95-7
No.	2	3	3	11	14	15	32	27	18	9	6	3
%	1.4	2.1	2.1	7.7	9.8	10.5	22.4	18.9	12.6	6.3	4.2	2.1

Probability scores ranged from 14 to 97, out of a possible total of 116 for all 58 questions correct. The mean score was 72.4 (SD = 11.9). Being a substantially new instrument there is little data with which to compare these results.

A range of competences was displayed in response to different groups of questions. The most difficult concepts of probability distributions could not be applied by a large majority of the sample. Majorities of respondents grasped basic combinations, understood basic randomness, and avoided the fallacy of expecting short run evening-up of results, for example *P2*, on Table 5. The responses showed quite low levels of competence on questions about independence, those about long run outcomes, and in the application of probability concepts to actual play. Looking at these questions individually, particular questions stood out for a high percentage of incorrect answers. Some are detailed in Table 5 below.

There was a high level of understanding of the significance of simple frequency of favourable outcomes, out of total possible outcomes, in determining likelihood. However, in application of this principle, difficulties arose in recognising the number of possibilities involved, particularly in combinations, and especially when a formal calculation was required. The first confounding factor seemed to be a prejudice in favour of the equality of possibilities. Only 54% picked that on one roll of a die an even number has a better chance of happening than a three. Almost all mistaken answers rated the possibilities as equal. The situation was worse distinguishing between the likelihood of two sixes compared with a six and a five, with 95% presumably not making any calculation, and rating these possibilities as equal *(P8*).

Applying the concept of independence to poker machines, which involves knowledge not just about probability, but about how the machines work, only a minority understood that each turn is entirely independent of the previous one (*L36*). Similarly, 77% did not understand that if a machine has just paid a big win, the chance of further wins on that machine is unaffected *(L32)*. Very few respondents (4.2%) understood the optimal play to maximise the chance of coming out ahead for 20 units played on a poker machine *(P19)*.

Table 5

Percentages Correct for Some Selected Questions

Item	Right	Unsure	Wrong
Independence			
L36. When playing pokies, the outcome from each spin is independent of the previous spin.	44.1	35.0	21.0
L32. If a poker machine has just paid a big win, the chance of further wins on that machine is reduced.	23.1	34.3	42.7
Simple probability, from numbers of instances of results.			
P8. Suppose two dice are rolled together. Which has the better chance of happening: 1. Getting two sixes? 2. Getting one five and one six? 3. Both have the same chance?	8.4	-	94.6
Short run evening-up fallacy			
P2. If you toss a coin you can get a head or a tail. You toss a fair coin and get four heads in a row. How many heads would you expect in the next 16 tosses?	51.1	13.3	35. 6
Understanding odds in context			
L33. Playing pokies, the chance of winning or losing is equal.	52.5	22.4	25.3
L18. I have an idea of how many plays, in total, I would get on a poker machine for an amount of money put in.	14.7	35.0	50.3
L23. If you bought a Lotto ticket every week, you would most likely win a First Division prize within the next 40 years.	58.0	28.0	14.0
P25. In a game where the house margin is 10%, (i.e. expected “player return” is 90%), how many games of $1 could you expect to play before $10 was used up?	12.6	-	87.4
P26. How would your answer above change if the house margin was 20%?	25.8	-	74.2
Long run outcomes			
L22. When playing pokies, there is more chance of coming out ahead from a short session than a long one.	24.5	32.9	42.7
P19. Poker machines allow for a number of bets (lines), and variable stakes (how much per line) on each play. If you made $20 worth of plays, which, if any, of the following playing strategies would give you the best chance of winning overall? Bet $1 on 1 line, and do it 20 times Bet $1 on 20 lines Bet $20 on 1 line All the same	4.2	-	95.8

The answers to some questions are difficult to interpret because of issues of relativity even though the questions are literally quite clear *(L22)*. You are not likely to come out ahead from a short session nor a long one, so it can be confusing to suggest that you are (relatively) more likely to come out ahead from a short session, when it is still unlikely that you will.

Under 15% declare that they would have an idea of how many pokie plays they would get for a set amount of money *(L18)*. This is evidence that the practical impact of the house margin over extended play is not understood in any detail. The misunderstanding is illustrated when 72% agreed that you are equally likely to lose whether you play pokies for a long or short time *(P11)*. Over 25% mistakenly agreed that the chance of winning or losing is equal *(L33)*. Another 22% were not sure. Do they think commercial gambling is a fair game? Only one out of eight respondents could make a reasonable estimate of how many plays you might get for 10 unit bets, if the average loss rate was 10% *(P25)*. When the house margin was changed to 20% from 10%, only a quarter of respondents indicated that you would expect fewer games for your money *(P26)*.

Exaggerated expectations applied to other games. Only 58% disagreed that you would most likely win first division Lotto in 40 years of weekly ticket purchases *(L23)*.

With a mean of 62.4% of questions correct (see Table 4), it was surprising that the overall level of understanding of probability concepts was so poor among so many university students.

Table 6
Relationships Between the Measures

Correlations r	Problem Gambling	Maths Skills	Probability Score
Gambling Frequency	0.48 ** (.000)	0.18 * (.034)	0.19 * (.022)
Problem Gambling		0.04 (.638)	- 0.16 (.059)
Maths Skills			0.43 ** (.000)

Log scales of Gambling Frequency and Problem Gambling were used. * $p < 0.05$ ** $p < 0.01$

The distributions on the measures of mathematics and probability knowledge were relatively Normal, as were logarithmic transformations of the gambling behaviour measures, passing tests for Kurtosis and skewness. Using logarithmic scales for the gambling measures made marginal differences to the results on the Pearson correlations.

Looking at the relationships between the results on the different instruments, Problem Gambling versus Gambling Frequency gave a highly significant medium positive correlation. Indeed, total gambling frequency was the strongest correlate of problem gambling. Although unsurprising, it does suggest the obvious, that attention to moderation of gambling frequency may be helpful in alleviating gambling problems. This result compares with earlier studies that report a positive significant, but less strong, relationship between gambling frequency and problem gambling (Moore and Ohtsuka, 2000).

Problem Gambling versus Probability Score gave a small marginally significant negative correlation, providing little support for the undifferentiated hypothesis that problem gambling will be associated with poor probabilistic understandings. But the Probability Score correlated in the other direction with Gambling Frequency, an interesting difference between levels of gambling activity and gambling problems.

There was no significant correlation between basic mathematics skills and gambling problems, suggesting that general maths knowledge *per se* is not relevant to gambling problems. However particular mathematical probability knowledge may be.

Mathematics Skills correlated weakly with Gambling Frequency, perhaps confirming that interest in a subject (gambling), is more likely with some understanding of it.

There was a moderate, highly significant, correlation between Mathematics Skills and the Probability Score, both partially measures of mathematical knowledge. It is perhaps surprising the correlation was not higher, suggesting that the individual mathematical development of participants is uneven across different mathematics topics.

Conclusion

Further analysis of the data, according to responses to questions grouped around particular probability concepts, may prove fruitful. The error rate was greatest in response to questions requiring application of probability knowledge to the actual context of gambling games. Further research to investigate levels of understanding of probability concepts, compared with gambling behaviour, seems warranted. Mathematics education could provide better understanding of the application of probability concepts to gambling contexts. It needs to provide understanding of the long-term expected outcomes from gambling on unfair games.

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