Why Gambling + Maths = An Unhealthy Addiction

A lot of things tend to come together to output an outcome in the subject of maths. $1 + 1 = 2$, $a^2 + b^2 = c^2$. However, what is rarely discussed is what the sum of gambling and maths equates to. Have you ever wondered why some people are really good at poker? **Or how do certain players excel at guessing games?** Well, the answer to this is maths and this essay will explain how.

To start, we need to understand the true meaning of gambling, a quick google search will tell you that gambling is when one **"[plays] games of chance for money; bet."**[1] A keyword to identify here is the noun "chance" which is often associated with probability – a well-known discipline of maths. Probability stems from gambling and the functions of probability are heavily used by mathematicians to assess risks, volatility, odds of winning, and expected values to give a numerical visualisation of whether a gamble is worth committing to[2].

Probability itself had quite an eventful discovery. The first idealisation of it occurred when mathematician, **Blaise Pascal** was summoned by a French nobleman **Chevalier de Méré** to solve a contradiction that arose in a popular dice game. The game worked by having players place bets on whether a constant dice thrown 24 times would land on a "double 6" (rolling two consecutive sixes) at least once. During those times, many believed that betting on a "double 6" would be profitable nonetheless, Méré did not concur with the idea which led him to exchange letters with Pascal to find a mathematical solution to solve the conundrum. Which they eventually did, forming the central principles of probability[3].

Despite the basics of probability only forming around 1654, gambling has been very prevalent in the wider aspect of history. The earliest evidence of the activity was found in China, 2300BC where the Chinese 'Books of Songs' referred to drawing wood which has led many historians to believe that tiles might have been used within a lottery-based game. This idea of making bets spread throughout the globe with Rome playing dice games in the street (500BC) and the first casino opening in Italy (1638). Fast forward to the modern-day, gambling has reached new heights with micro gaming making an appearance in 1994 as well as present virtual gambling[4]. **But what has maths got to do with this?**

Figure 1 - Casino Di Venezia (2016 photo of the first casino built)

[1] Oxford Languages [https://languages.oup.com/google-dictionary-en/ Last Accessed: 25 March 2021]

[2] Akusobi C., "Should You Bet On It? The Mathematics of Gambling", *Yale Scientific* 25 February 2010. [https://www.yalescientific.org/2010/02/should-you-bet-on-it-the-mathematics-of-gambling/#:~:text=Generally%2C%20skilled%20gamblers%20assess%20the,a%20bet%20is%20worth%20pursuing. Last Accessed: 25 March 2021]

[3] Apostol T., "Calculus, Volume II", *John Wiley & Sons* 1969.

[4] Gambling.net, "The History of Gambling", *Gambling.net* 2021 [https://www.gambling.net/history/ Last Accessed: 25 March 2021]

Figure 1 – Horridge K., "Which Is The Oldest Casino In The World? Find Out!", *Casino.org* 18 January 2016. [https://www.casino.org/blog/which-is-the-oldest-casino-in-the-world-find-out/ Last Accessed: 25 March 2021]

Let's start with a very basic game – **Rock, Paper, Scissors**. Personally, I believe this game should be classed as a form of gambling because it is a volatile system often used by children where stakes are put on winning e.g., the winner gets to play with the skipping rope first. There are many legitimate methods mathematicians use to dominate this game via probability however I will be focusing on the infamous academic **Zhijian Wang's methodology**. He uses a persistent cyclic flow to win the game; the trick goes like this:

1. We have two players, Player 1 and Player 2.
2. Both pick a random choice, to begin with.
3. If Player 1 uses rock and Player 2 uses scissors then Player 2 loses.
4. In Round 2, Player 2 should assume that Player 1 will use rock again because they won with it previously. Therefore, Player 2 should pick paper to win.
5. In the latter round, Player 1 will use the cycle (as shown in Figure 1) to pick their choice proceeding from rock which is paper. Therefore Player 2 should use scissors to win.
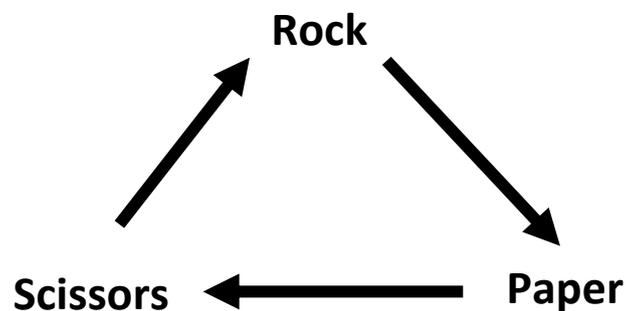

Figure 2 - Rock Paper Scissors Flow Diagram

The reason this works mathematically is because the strategy is loosely based on Nash's equilibrium. This means that players should try and pick all **3** items **1/3** of the time as the end result can only be a win, lose or draw. Zhijian's method is slightly different because, through his research, there was a particular pattern he spotted where players who win tend to stick with their item because of confidence whereas, losers move on to the next item in the sequence[5]. Due to human's predictable irrationality mathematicians have been able to exploit rock, paper, scissors by the use of **Game Theory**.

Another system that has been created over the years to combat gambling mathematically is the **Martingale Betting System**. This is a simple practice to execute that has been around since at least the 18th century. It works through doubling your losing bets until you win[6]. Here is a scenario:

- You place a £1 bet on an outcome.
- If you win: You set that £1 aside and bet another £1
- If you lose: You will bet £2 on your next go

[5] Jacobs H., "A Chinese Mathematician Figured Out How To Beat Anyone At Rock-Paper-Scissors", *Business Insider* 2 May 2014. [https://www.businessinsider.com/how-to-beat-anyone-at-rock-paper-scissors-2014-5?r=US&IR=T Last Accessed: 25 March 2021]

[6] Kilbridge D., "THE MARTINGALE SYSTEM AND SPORTS BETTING", *Bookies* 2 July 2020. [https://bookies.com/guides/martingale-system Last Accessed: 25 March 2021]

These steps then continue iteratively until you win or are satisfied with your total outcome. If the player ends at the point at which they win then said player will end up with a net profit of 0 denoting that they made no profit (unless you win on the first go).

In a two-outcome event, this can be generalised to[7]:

⇨ Let the number of losses in a game = n

⇨ Chance of losing n times in a row = $\frac{1}{2^n}$

⇨ ∴ winning probability = $1 - \frac{1}{2^n}$

⇨ Winning gain = 2

⇨ If player loses then the loss is the sum of all previous loses = $(2 + 2^2 + 2^3 + ... + 2^n) = 2^{n+1} - 2$. This should all be multiplied by negative as it is a loss from the original value ∴ $-(2^{n+1} - 2)$

⇨ This then goes into an expectation formula (Expectation = P(Winning) × Gain + P(Losing) × Loss). This is $2(1 - \frac{1}{2^n}) - \frac{1}{2^n}(2^{n+1} - 2)$ which eventually cancels out to 0 our net expectation/profit. This is the value that we should expect to get from playing the game until winning.

The Martingale Betting system is extremely effective in **perfect conditions** highlighting that players have an infinite bankroll to sustain in addition to this, no wager limits. Nevertheless, this rarely occurs. The main reason for this is that most casinos have caps on bets to ensure that this phenomenon does not happen ergo, making perfect conditions infrequent.

As we have discovered maths can be used in a very creative way to take advantage of gambling within perfect conditions. However, this is never the case as online hotspots and casinos also use their methods of reasoning to make sure that odds are stacked against players – no matter how mathematically able you are. Despite this, risk-based maths can be used positively in regions such as actuarial science that assess the risk of finance and insurance to maintain economic stability.

Yet in the case of gambling, maths may give you a slight advantage in the short term but if anything, the long-term effect leads to a higher level of negative externalities than the average participant. The more **adrenaline** you receive from your initial win, the more likely you are to put further money on placing bets. Sometimes this is more than one can afford leading to debt, neglection of the ones close to them, irrational behaviour as well as criminal engagement[8]. This is why Gambling + Maths = An Unhealthy Addiction.

[7] Looking Glass Universe, "Why The Martingale Betting System Doesn't Work", *YouTube* 15 July 2017. [https://www.youtube.com/watch?v=Ry3B9hJbBfk Last Accessed: 25 March 2021]

[8] Mental Health, "Gambling and mental health", *Mental Health* [https://www.mentalhealth.org.uk/a-to-z/g/gambling-and-mental-health#:~:text=When%20gambling%20becomes%20a%20problem&text=you%20spend%20more%20money%20on,your%20family%20or%20your%20work Last Accessed: 25 March 2021]

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