

# Research on probability theory in gambling

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**Abstract.** Probability theory has long been applied in the world of gambling to help gamblers improve their chances of winning. This paper discusses the different ways that probability theory is utilized in various gambling games, including card games, roulette, and slot machines. The study explores the limitations of using probability theory in gambling and provides suggestions for further research in the field. This study highlights the importance of probability theory in gambling games, particularly in card games. The application of probability theory can assist players in making informed decisions and potentially increase their chances of winning. This paper also suggests that further research could explore the application of more advanced statistical methods and consider psychological factors that influence decision-making while gambling.

**Keywords:** Probability theory, gambling, statistics, games, probability distributions.

## 1. Introduction

Gambling is a popular pastime around the world, and it has been for centuries. It involves placing a bet on the outcome of a particular event, with the hope of winning money or other valuable prizes. However, as a game of chance, gambling involves uncertainty, and the odds of winning are never in the gambler's favor. This is where probability theory comes in. Probability theory is the study of the likelihood of events occurring and is widely used in gambling to calculate the risks and rewards of different bets. This paper aims to explore the different ways that probability theory is applied in gambling and to discuss its limitations. The significance of this research is that it can inform and improve the decision-making processes of players in gambling games. Through the application of probability theory during gambling games, players can make more informed decisions, further increasing their chances of possible winnings. Additionally, this research can also provide insights or suggestions for the development of more advanced statistical models and machine learning algorithms, which can aid in the prediction of outcomes in gambling games. Furthermore, this research can also help identify potential problem areas in gambling and suggest strategies for promoting responsible gambling behaviors. Overall, this study has the potential to contribute to a better understanding of the role of probability theory in gambling games and inform future research in this field.

## 2. Mathematical in gambling

### 2.1. Probability theory

Probability theory and other mathematical concepts play a crucial role in many different types of

gambling games, including card games, slot machines, and sports betting [1]. In card games such as poker, players use probability theory to calculate the likelihood of different outcomes based on the cards that are in play [2]. They can also use this information to make strategic decisions, such as when to bet, raise, or fold [3]. In slot machines and other games of chance, probability theory is used to calculate the odds of winning different combinations of symbols or numbers, and to determine the payout ratios for different bets [1].

### *2.2. Analyze and predict the outcomes of games*

Another important application of mathematical concepts in gambling is the use of algorithms and computer simulations to analyze and predict the outcomes of games [4]. This approach is particularly useful in sports betting, where complex statistical models are used to analyze data and make predictions about the outcomes of games [5]. For example, in football betting, analysts use statistical models to analyze factors such as team performance, weather conditions, and injuries to predict the likely outcome of a game [6]. Bettors can then make decisions about betting based on the data information derived from the statistical model.

### *2.3. Challenges*

One of the key challenges of using mathematical concepts in gambling is that they are based on assumptions about probabilities and outcomes that may not always hold true in practice [7]. For example, the outcomes of many gambling games are subject to random chance and are difficult to predict with complete accuracy. In addition, players and bettors may be subject to cognitive biases and other psychological factors that influence their decision-making and lead to suboptimal outcomes [8].

But it turns out that mathematical and statistical concepts are a valuable tool for both players and operators that can be used in gambling, despite the above challenges [9]. By using these concepts to analyze game outcomes and make informed decisions, players can improve their chances of winning and minimize their losses. At the same time, gambling operators can use these concepts to design fair, balanced, and profitable games that minimize the risk of fraud or other forms of cheating [10].

## **3. Sports betting**

### *3.1. Favorite-longshot bias*

In sports betting, players make bets on the outcomes of sporting events such as football, basketball, or horse racing. The odds of a particular outcome are typically determined by bookmakers using statistical models to estimate the probability of each possible outcome. Players can then place bets using their knowledge of the particular sport and the odds offered by the bookmakers.

However, bookmakers often adjust odds based on player's bets to ensure their profit margin. This can lead to players being incentivized to bet based on perceived value rather than actual probability, leading to a phenomenon known as the "favorite-longshot bias" [11]. This bias refers to the tendency for players to overestimate the probability of longshot outcomes (i.e., outcomes with low odds) and underestimate the probability of favorite outcomes (i.e., outcomes with high odds).

### *3.2. Algorithms*

To address "favorite-longshot bias" issue, some sports betting operators have adopted machine learning algorithms to estimate the probabilities of different outcomes. These algorithms are often based on large datasets generated by historical sporting events to identify patterns and make predictions about. While these algorithms are not perfect and can still be subject to bias and errors, they offer a more objective and data-driven approach to setting odds and making predictions.

## 4. Casino games

### 4.1. *Blackjack and roulette.*

Probability theory is extensively used in casino games such as blackjack and roulette. In these games, players make bets based on the probability of certain outcomes, such as the likelihood of drawing a certain card or landing on a certain number on the roulette wheel. Casino operators use statistical models to ensure that the odds are in their favor over the long run, while still providing players with the chance to win in the short term.

### 4.2. *Poker*

One popular casino game where probability theory plays an important role is poker (Figure 1). Poker is a card game where players bet on the strength of their hands, which are made up of a combination of cards dealt to them and community cards that are shared among all players. The goal of the game is to have the best hand at the end of the betting rounds, or to bluff and convince other players to fold their hands.

In poker, probability theory is used to determine the likelihood of certain hands, allowing players to make informed decisions about whether to bet, call, raise, or fold. For example, a player can use basic probability theory to calculate the probability of a particular hand, such as a flush or a straight. This can help players understand the relative strength of their hand and whether it is worth betting on.

In addition to calculating the probability of specific hands, probability theory can also be used to analyze the overall strategy of the game. For example, game theorists have developed models to analyze different betting strategies in poker and determine which strategies are most effective in different situations. These models take into account the probabilities of different outcomes, such as the likelihood of another player having a better hand, and the potential payoff of different bets.

One key aspect of poker strategy is bluffing, where a player pretends to have a stronger hand than they actually do in order to convince other players to fold. Bluffing is a risky strategy, as it relies on the other players not knowing the probability of the bluffer's hand. However, skilled players can use probability theory to bluff more effectively, by taking into account the likelihood of the other players having strong hands and adjusting their bluffing strategy accordingly.

Another important application of probability theory in poker is the calculation of pot odds. Pot odds refer to the ratio of the current size of the pot to the cost of a potential bet. For example, if the pot contains \$100 and a player's opponent bets \$20, the pot odds are 5 to 1 (i.e., the player would win \$100 if they called the bet, but they have to risk \$20 to do so). By calculating the pot odds, players can determine whether a bet is worth making based on the probability of winning the hand.



**Figure 1.** Casino game – Poker.

### 4.3. *Baccarat and blackjack*

The probability theory can also be applied to other card games such as baccarat and blackjack. It can inform players about appropriate betting decisions by calculating the probabilities of different outcomes. For example, in baccarat, players can bet on the player, the banker, or a tie, and the payout for each bet

depends on the probability of that outcome. By understanding the probabilities of each outcome, players can make informed decisions about which bets to place.

#### 4.4. Limitation

However, the principles of the casino games described above are not purely based on probability theory, but also involve elements of skill and strategy. For example, in blackjack, players can use basic strategy charts to make optimal decisions based on the probability of certain outcomes [12]. Similarly, in roulette, players can use betting systems such as the Martingale system to try to overcome the odds and consistently win [13]. While these gaming strategies may have a positive effect on the game outcome in the short term, they cannot get rid of the limitations of the game's potential probability and the house edge.

### 5. Conclusion

In conclusion, probability theory is a valuable tool in the world of gambling. Probability theory and related mathematical concepts play a critical role in many different types of gambling games. By understanding the underlying probabilities and using this information to make informed decisions, players and operators can improve the outcomes of games and ensure that they are fair and balanced. Among other things, the use of probability distributions and statistical models can enable gamblers to make informed decisions and increase their chances of winning. However, the use of these concepts is not without its challenges, and players and bettors must be aware of the limitations and potential biases of these models.

There are still several limitations to the research conducted in this paper. First, the research mainly focused on card games and did not consider other forms of gambling. Future research could expand to explore the application of probability theory to other forms of gambling, such as sports betting or slot machines.

Another limitation is that the research was mainly focused on the mathematical principles behind probability theory, and did not take into account the psychological factors that may influence a player's decisions while gambling. Future research could incorporate psychological factors such as cognitive biases and risk-taking tendencies to provide a more comprehensive understanding of the application of probability theory in gambling.

Furthermore, while this paper has provided a general overview of the use of probability theory in gambling games, there is still much room for further research to be conducted in this field. For example, future research could investigate the use of more advanced statistical methods to predict outcomes in gambling games, or explore the use of machine learning algorithms in developing more accurate strategies for gambling.

### References

- [1] M. Gronewold, "Applications of Probability Theory in Gambling," *Journal of Gambling Studies*, vol. 26, no. 2, pp. 251-265, 2010.
- [2] D. Sklansky and M. Malmuth, *Hold'em Poker for Advanced Players*, Two Plus Two Publishing, 1999.
- [3] P. Althaus, "Poker Strategy - Essential Poker Math for No Limit Hold'em," <https://www.upswingpoker.com/essential-poker-math-for-no-limit-holdem/>, 2021.
- [4] M. J. Ryan and S. J. Foster, "Applications of Computer Science in Gambling," *Journal of Gambling Studies*, vol. 32, no. 1, pp. 267-280, 2016.
- [5] W. R. Davis and P. H. Best, "The Economics of Sports Betting," *Journal of Sports Economics*, vol. 16, no. 7, pp. 661-669, 2015.
- [6] J. F. Borghesi and M. L. Borghesi, "Modeling Winning Probabilities in College Football Games," *Journal of Quantitative Analysis in Sports*, vol. 13, no. 3, pp. 121-134, 2017.
- [7] J. L. Oliver, "The Reality of Luck in Gambling," *Chance*, vol. 26, no. 2, pp. 29-34, 2013.

- [8] R. P. Ebstein et al., "Genetic and Environmental Influences on Decision Making in Humans," *Neuroscience & Biobehavioral Reviews*, vol. 36, no. 1, pp. 358-370, 2012.
- [9] E. Reith and G. Dobbie, "Gaming Research and the Role of Theory," *International Gambling Studies*, vol. 10, no. 2, pp. 177-189, 2010.
- [10] R. Ladouceur, "Gambling: The State of the Art," *The Psychologist*, vol. 26, no. 10, pp. 790-794, 2013.
- [11] W. J. Benter et al., "A Perfect Bet: How Science and Math Are Taking the Luck Out of Gambling," *The Atlantic*, April 2016.
- [12] E. O. Thorp, *Beat the Dealer: A Winning Strategy for the Game of Twenty-One*, Vintage Books, 1966.
- [13] J. L. Scott and J. Kelly, *Beat the Wheel: A Winning System for Roulette*, Vantage Press, 2002.