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How rational is gambling?

Robin Maximilian Stetzka | **Stefan Winter**

Economics, Ruhr University Bochum, Bochum, Nordrhein-Westfalen, Germany

Correspondence
Robin Stetzka, Faculty of Economics, Ruhr University Bochum, Bochum, Nordrhein-Westfalen, Germany.
Email: robin.stetzka@ruhr-uni-bochum.de

Abstract

The typical gambler loses money but continues to gamble nonetheless. Why? Research from orthodox and behavioral economics, psychology, sociology, and medicine has offered a wide range of possible explanations. This paper reviews these explanations. The evidence is organized according to the degree of rationality assumed and/or found in the studies. This approach allows research from highly distinctive fields to be integrated within a unified framework. Gambling patterns are so highly dispersed that no satisfying one-fits-all explanation is possible. The findings suggest that the whole spectrum from rationality to highly destructive irrationality can be found within the gambler population.

KEYWORDS
bounded rationality, consumption benefits, gambling, gambling behaviour, irrationality, rationality

1 | INTRODUCTION

Gambling is a human activity with a long history (for a vivid account see Schwartz, 2007). Gross gaming revenue (GGR) across the European gaming market (EU-27 and the UK) in 2019 was estimated as €98.6bn, of which €24.5bn was in the online market and €74.1bn in the land-based market. The GGR in the EU-27 and the UK is expected to grow to €111bn by 2025 (see EGBA, 2020). In 2017, US citizens spent nearly $72bn plus commissions on lotto games alone (see US Census Bureau, 2017).

Williams et al. (2021) show in their prevalence study in Canada that 66% of 23,952 participants had engaged in some form of gambling at least once in 2018. Similar results (68.5%) were obtained for the year 2015 in a representative sample from the Spanish population by Chóliz et al. (2019).

The gambling industry is thus an important economic sector. It therefore comes as no surprise that gambling has not only triggered political interest and regulation, such as the Unlawful Internet Gambling Enforcement Act of 2006 in the US or the Rennwett- und Lotteriegesetz (Racing Betting and Lottery Act) of 1922 in Germany, and many others, but has also attracted much scientific inquiry.

There are gamblers that make money from gambling (see e.g., Chellel, 2018; Fowler, 1996; Kucharski, 2016; Levitt, 2004; Murphy, 2018; Paul & Weinbach, 2002). They do so by employing superior strategies, by using insider information, or by manipulating events and markets. The empirical literature has shown that superior betting strategies exist under certain circumstances (see Hausch et al., 1981; Levitt, 2004; Paul & Weinbach, 2002, 2012; Ziemba & Hausch, 1985, 1987). For example, strategies based on arbitrage opportunities sometimes offer positive expected returns (see Franck et al., 2013; Vlastakis et al., 2009). Moreover, insiders might be able to make profits using their superior information (see Bizzozero et al., 2018; Brown, 2012; Marginson, 2010; Paton et al., 1999; Schnytzer & Shilony, 1995). Finally, there is also evidence for match fixing and other forms of manipulation leading to positive returns for the cheaters (see Anderson, 2012; Forrest, 2017, 2018; Forrest et al., 2008; Park et al., 2019).

Yet, the majority of gamblers experience negative returns from their activities. So presumably, one of the most interesting gambling-related questions of all is why the majority of gamblers gamble at all and why most of them continue to do so despite the fact that they lose money on average. This problem has attracted and still attracts scientists from various disciplines (see Beckert & Lutter, 2012; Conlisk, 1993; Neighbors et al., 2002; Quandt, 1986; Rachlin, 1990). The following survey is dedicated to organizing and classifying the multitude of answers to this question offered by economists, psychologists, sociologists, and physicians. We organize the literature according to the degree of rationality assumed to explain the observed gambling patterns. The paper covers the whole continuum ranging from rational gamblers to completely irrational gambling addicts that ruin their lives (see Allami et al., 2021; Park et al., 2010; McIntyre et al., 2007; Kim et al., 2006; Ladouceur, 1996).

As outlined above, some gamblers do indeed make money by gambling. It can be argued that these gamblers' behavior closely resembles that of financial investors. What is more, their activities are most easily reconcilable with the assumption of rational behavior. Since this review concentrates on the majority of gamblers, that is, those that lose money, we will not review the evidence on the minority of money makers here in any more detail.

However, for solely financially motivated agents, making money is not a sine qua non for rationality. If behavior is driven by financial motives alone, gambling that loses money on average could still be regarded as rational if gamblers are assumed to be risk lovers (see Quandt, 1986; Ali, 1977). Even this explanation is not exhaustive, however. Gambling for financial reasons alone combined with expected losses could also be rational if the gambles sufficiently diversify the investment portfolio of a gambler. This line of reasoning refers to the ideas of capital asset pricing (see e.g., Copeland et al., 2005; Lintner, 1965; Sharpe, 1964). A third explanation could be that a gambler expects to derive high utility from being a millionaire but sees no alternative to become one by playing for example lotto.[1]

[1] We thank an anonymous reviewer for suggesting this third alternative.

But, as will be shown, neither the risk love explanation nor the diversification arguments are convincing. The most fundamental reason for the rejection of the risk love and diversification explanations is that there is much evidence of gamblers accepting stochastically dominated wagers, suggesting that the price they pay for their risk love or their risk diversification is too high. We thus reject the rational risk love explanation as well as the rational diversification explanation. It must be noted, however, that these conclusions refer to rational gamblers only. For boundedly rational bettors things might be different as they might not know about the existence of dominant bets or better diversification opportunities. With respect to the third alternative, for example, deriving a high utility from being a millionaire with no alternative but lotto to become one, we can offer no judgment as studies in the field do not document the available alternatives of gamblers.

If one drops the assumption of purely financial motives, gambling could be interpreted as a consumption activity (see Mao et al., 2015a, 2015b; Paul & Weinbach, 2010, 2014; García et al., 2008). Consumers of gambling services could thus be seen as rational economic agents purchasing a commodity that offers entertainment and excitement, as well as some hope of acquiring a higher level of income and wealth (see Eadington, 1975, 1999).

We document patterns of gambling behaviors that are in line with non-financial considerations, suggesting that some of the gambling population do not play, or do not only play for financial reasons (see Agha & Tyler, 2017; Humphreys et al., 2013a; Franck et al., 2011).

On the other hand, the monetary consequences of gambling do not seem completely irrelevant to gamblers, even if their main motives might be non-financial (see Conlisk (1993) for a model of combined motives). While gamblers show behaviors indicating that they also care about the monetary outcomes, it is nevertheless observable that they often use financially suboptimal strategies. Using suboptimal betting strategies is not restricted to beginners, so suboptimal wagers are not simply attributable to a lack of experience. For example, even after several years of daily gambling, blackjack players were found not to use optimal strategies (see Wagenaar et al., 1984). Such findings may indicate non-financial motives, but they may also indicate bounded rationality (see Simon, 1955, 1957, 1959).

In order to categorize and classify the findings from such distinct fields as economics, psychology, sociology, and medicine we use the degree of rationality documented in the studies. While rationality should be understood as one of a cardinally scaled variable, we chose to differentiate the studies into three categories ordered only ordinally. We did so because the findings in the literature do not allow us for a finer classification. Even the ordinal scale we use does not always allow to classify findings unequivocally. We differentiate between the three categories labeled *rationality*, *bounded rationality*, and *irrationality*. We delineate the borders between the three categories by the logic of the decisions made and by the degree of control the individual has over his/her behavior.

While the distinction between rationality (see Selten, 2000; Becker, 1962) and bounded rationality (see Simon, 1959, 1957, 1955) is rather straightforward and has a long tradition within economics, the definition of irrationality is less clear. Some authors argue that irrationality is simply the absence of full rationality (see e.g., Mandler, 2014; Becker, 1962). But such a delineation does not draw a clear line between irrationality and bounded rationality. We therefore followed another approach, one that refers not to the logical considerations behind decisions but to the locus of control of gamblers' decisions. If gamblers can control their behavior, we treat them as rational or boundedly rational agents.

If, on the other hand, gamblers lose control over their behavior, we classify their behaviors as irrational. Loss of control might be due to illogical reasoning, a phenomenon widely documented (see Kovic & Kristiansen, 2019; Källmén et al., 2008; Walker, 1992). Loss of control can even be complete and thus lead to ruinous gambling (see Moore & Ohtsuka, 1999; Toneatto, 1999). Since there is ample evidence of gamblers losing control, it can be concluded that small parts, but only small parts, of the gambler population are irrational.

The paper proceeds as follows. In Chapter 2 we will give definitions of the three categories of rationality mentioned above. These form the basis of our classification of gambling behaviors. In Chapter 3 we consider only those gambling explanations that are based on the assumption of rationality. Chapter 4 addresses gambling as boundedly rational behavior. In Chapter 5 we deal with gambling as irrational behavior.

2 | DEFINITIONS

We start by defining the three rationality concepts that are used throughout this paper, that is, full rationality, bounded rationality and irrationality.

2.1 | Full rationality

Within microeconomics, rational decisions are characterized by well-organized, stable and transitive preferences (see Becker, 1962; Simon, 1955). Stable preferences, maximization of utility and unlimited cognitive skills combined with complete self-control are the main assumptions behind homo oeconomicus (see Selten, 2000), the prototype of a rational human being. Selten (2002, p.14) describes this fully rational human as “a mythical hero who knows the solution of all mathematical problems and can immediately perform all computations, regardless of how difficult they are”. The rational agent can always find and will always chose the best available option (Simon, 1955, 1997; Savage, 1954). For the purpose of this paper we define rationality as characterized by utility maximization, stable preferences and complete self-control. The rational agent never uses heuristics and has no cognitive biases or other cognitive limitations.

2.2 | Bounded rationality

The assumptions behind the full rationality concept usually seem too strong to represent the decisions of real-world agents. For this reason, Simon (1955, 1957, 1959) suggested the concept of bounded rationality. Bounded rationality is characterized by the relaxation of at least one of the assumptions behind full rationality. Relaxations refer to what is known about real-life human behavior, especially about decision-making processes (see Simon, 1990, 1997). One of the most influential theoretical developments based on bounded rationality is prospect theory developed by Kahneman and Tversky (1979), who were among the first authors to draw attention to the emerging field of behavioral, nonrational economics (see Tisdell, 2017; Kahneman, 2003; Kahneman & Tversky, 1979).

Conlisk (1996) reports a large number of observed violations of full rationality. These violations were detected in experiments and field studies. They provide strong evidence supporting Simon’s concept of bounded rationality. People may make mistakes in their calculations due to limited capabilities, and they have neither full information and knowledge, nor an absolute degree of self-control or willpower (see Beck, 2014; Simon, 1990, 1997). Simon (1959) claims that people are likely to use a "stop rule" rather than a complete maximization approach. Accordingly, people do not search for the best option but rather accept a certain aspiration level and stop searching as soon as they find a sufficient option (see Simon, 1997).

Another important aspect of bounded rationality is the use of heuristics. Heuristics are rules of thumb. These rules are simplifications and reduce the complexity of calculations and information gathering. Therefore, heuristics allow people to make decisions based on limited resources. These heuristics might be quite useful, but they may also lead to systematic errors (see Conlisk, 1996; Tversky & Kahneman, 1974). The use of heuristics which lead to errors and fallacies in judgments or decision making is thus representative of boundedly rational behavior (see Gigerenzer, 2002).

It is important to point out that people who behave in a boundedly rational way due to one of the above-mentioned reasons are still engaging in the process of optimization. These processes might lead to suboptimal decisions due to those imperfections, but the decision-makers are still trying to optimize (see Doucouliagos, 1994).

The use of heuristics, misperceptions of probabilities, and erroneous calculations due to limited capabilities or insufficient information are thus indicators of boundedly rational behaviour.

2.3 | Irrationality

The definition of irrationality is less clear, with less of a consensus. One approach is to define irrationality negatively as anything that falls short of rationality. An example is Becker (1962), who claims that any deviation from utility maximization indicates irrationality. Similar arguments are put forth by Mandler (2014), Sorensen (1991), and Žeželj and Lazarevic (2019). Some authors use specific deviations from rationality to define irrationality, such as intransitivity of preferences (see Toth, 2013).

Yamane et al. (2012) delimit irrationality by the degree of belief in paranormality and the degree of non-scientific thinking. There is strong evidence that unsustainable beliefs are shared by many problem gamblers (see Armstrong et al., 2020, 2020a, 2020b; Cosenza et al., 2019; Leonard, 2018; Yuan, 2015; Emond & Marmurek, 2010; Joukhador et al., 2004; Griffiths, 1994; Walker, 1992; Gaboury & Ladouceur, 1988). For example, pathological gamblers have continuous beliefs that they will win big money (see Moore & Ohtsuka, 1999; Toneatto, 1999). Banz & Lang (2017) found a positive relationship between irrationality of beliefs and levels of problem gambling.

Another approach is taken by Simon (1993), who explains that irrational behavior is behavior that is not linked to any goals. While Simon (1993) refers to a lack of goals, Baudin (1954) refers to lack of consideration, defining rational processes as those processes that follow the sequence: stimulus-reason-response. If, on the other hand, a stimulus finds no motivation in the brain, there will be no reasoning, and thus the process can be labeled irrational. This type of decision making therefore refers to the stimulus-response paradigm of behaviorism (see Skinner, 1971).

Baudin (1954) adds that there are processes of the kind stimulus-response-reason, when a cognitive motivation is invented afterwards. These kinds of processes remain irrational, but the individual is tricked by his/her own brain into believing that he/she has made a rational choice. In many experimental studies, it has been found that in some instances decisions have already been made a few seconds before these decisions are consciously recognized by the individual (see Bode et al., 2011; Fried et al., 2011; Soon et al., 2008). Decisions may thus be made unconsciously/irrationally but are perceived to be conscious/rational decisions.

But again, the merits of such a definition are limited for most empirical settings of interest here, since only the behavior, and not the brain processes driving that behavior, is observable. However, we would not preclude the use of such an irrationality concept for those empirical research settings that make use of brain activity data during gambling, as is done in the neuroeconomics approach (see e.g., Camerer et al., 2004, 2005).

A completely different view is taken by authors who approach gambling from a psychological/medical perspective. Here, lack of control is the central concept used to identify so-called problem gambling. For example, the International Classification of Diseases (ICD) of the WHO, which offers definitions of all injuries, disorders, diseases, or other health-related conditions (see WHO, 2019), states that problem gambling is characterized by a lack of self-control (see ICD 10, 2019). This lack of control may even lead to self-defeating or self-destructive consequences (see Ellis, 1976). In the same vein, the American Psychiatric Association defines pathological gambling as "persistent and recurrent maladaptive behavior, characterized by an inability to control gambling" in their fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-4) (Blaszczynski & Nower, 2002, p.487; APA, 1994).

There is evidence that problem gambling is indeed mainly driven by a loss of control (see Banz & Lang, 2017; Bergen et al., 2012). In loss of control situations, individuals might even be aware or believe that they are behaving, without adequate reasons, in a way that is harmful to themselves or others (see Gert, 1990). Prevalence studies on problem gambling mainly employ the South Oaks Gambling Screen (SOGS) questionnaire or the Problem Gambling Severity Index (PGSI), both derived from different versions of the above-mentioned DSM of the American Psychiatric Association. Empirical evidence suggests that of the items covered by the SOGS or the PGSI, those related to loss of control have the highest discriminating power between groups of medium and high severity problem gamblers (see James et al., 2016).

Thus, one reasonable way to define irrational behavior is by referring to loss of control. The advantage of a definition using loss of control compared with the approaches discussed above is its superior observability. If people can be observed for some time or can deliver self-reports, loss of control should be empirically detectable. We follow this approach, and in what follows we define irrationality as gambling behavior that suffers from a loss of control.

2.4 | Summary and interpretation

We have suggested three different rationality concepts in order to summarize and categorize different gambling patterns. First, agents could behave rationally. These agents would maximize their utilities, have stable preferences and be fully self-controlled. Furthermore, they would make no mistakes in their calculations and would have no cognitive limitations relating to the gambling situation.

If agents still try to optimize, but one or more of the above characteristics of full rationality are missing, their behavior is labeled as boundedly rational. Boundedly rational behavior is characterized by the use of heuristics, by stop rules based on satisfaction instead of optimization, and by mistakes in calculations and forecasts. In any case, boundedly rational agents still have sufficient self-control.

Thirdly, people could behave irrationally. This happens when they suffer from a lack of self-control.

These three concepts are used to categorize the highly dispersed patterns of behaviors observed in gambling markets. Before doing so, we need to discuss the limitations of categorizing empirical findings according to these rationality concepts. We see two main limitations.

One limitation is due to the fact that most gambling studies report observed behavior but not the available alternatives that the gambler could have chosen instead. This implies that even behavior which looks fairly rational might not be rational at all. For example, there are a couple of accounts of highly successful gamblers. Some of them made fortunes by effectively exploiting their knowledge, capabilities and information. One strategy is the exploitation of jackpots in lotteries (see Murphy, 2018; Kucharski, 2016; Fowler, 1996).

These large and sometimes even long-lasting financial successes indicate that the users and profiteers of these strategies used some kind of optimization approach and thus could be considered rational. However, there is no information on whether these agents really became happy, or whether instead they would have had much better lives as rural chicken breeders. In that latter case, their activities in gambling markets could no longer be considered rational.

Our categorization should thus be understood as a "would be" categorization. Making millions of dollars by some clever exploitation of an ill-designed lottery is regarded as rational because it would be classified as rational if it were the behavior chosen by someone who is motivated by money alone and who has no better alternative.

The other limitation is a lack of clear-cut boundaries between the rationality concepts. If, for example, someone derives a consumption benefit from the pure act of gambling, that person may make financially erroneous decisions, but is fully compensated for his/her losses by the fun of gambling, and thus could be regarded as rational despite his/her financial losses. Spending money on a wager could simply be an entertainment investment, just like going to the cinema. But just as spending money on a cinema ticket can hardly be considered irrational per se, spending money on a wager that is fun also cannot be regarded as irrational.

The problem arises from the fact that typically only the wager is observable, while the fun, or more generally the consumption benefit, is not. Whether a wager is made by a rational gambler having fun or by a boundedly rational gambler who hates to lose money cannot be inferred from the wager alone. In that sense, many of our delineations are subjective.

3 | FULL RATIONALITY

In this section, we look at the rationality of gamblers from three distinct perspectives. In subsection 3.1 we briefly look at aggregate market outcomes and ask whether these outcomes are reconcilable with the assumption of rational market participants. The main result of this subsection suggests that market outcomes are regularly driven by efficient use of available information, suggesting a high degree of rationality in gamblers and bettors.

In subsections 3.2 and 3.3. we look at the rationality of gamblers and bettors from an individual point of view. Both theoretical and empirical studies considering this view vary in their assumptions regarding the drivers of utility. One stream of research, addressed in subsection 3.2, assumes that gambling is a pure investment activity that is solely evaluated according to its financial consequences. Another stream of research, addressed in subsection 3.3, assumes that gambling is at least to some extent also a consumption activity. The former stream assumes that utility is affected neither by the act of gambling itself, nor by any other, non-financial consequences of gambling. In contrast, the latter stream assumes that while the financial effects may still be considered, utility is also affected by the gambling itself and/or its non-financial consequences.

3.1 The market view

In the market view, the rationality of market participants is judged by the conceivability of market outcomes. If bettors and gamblers react appropriately to the economic incentives created by markets, then at least at the macro level, one could say that markets are driven by rational considerations. At the heart of this debate is the question of whether gamblers and bettors make efficient use of available information. If so, the demand for gambles should depend on those gambles' properties and should react to changes of these properties in an economically reasonable way.

For example, Eadington (1999) notes that American roulette, with its additional double zero as compared to French roulette, is about twice as expensive as the latter from the gambler's perspective. Roulette is only a minor table game in the US but a major source of returns for casinos in Great Britain, where French roulette is used. This pattern of demand is consistent with the different price characteristics of American versus French roulette and is therefore indicative of rational considerations by players.

In the following, we will concentrate on the lottery demand literature, as well as the betting market literature that addresses the forecasting value of odds. These market views suggest that at least at the aggregate level, gamblers, and bettors use information quite efficiently, indicating rational considerations in gambling- and betting-related decisions.

Economists have long been intrigued by the popularity of lotto games despite their typically poor return expectations (see Baker et al., 2020). One possible explanation, however, is that buying a lottery ticket is buying a dream (see Forrest et al., 2002). If that explanation is correct, lottery players would be expected not to spend additional money on other gambling activities that do not offer life-changing wins. In fact, as Brunk (1981) found out from a national US survey, respondents' dissatisfaction with their current income predicted participation in lotteries but not in other gambling activities that do not offer extreme wins. Escaping from poverty might indeed be one major motive for participating in lotteries, as sales of lotto tickets and poverty rates are significantly positively associated (see Blalock et al., 2007).

A special feature of lotto games is the existence of jackpots and jackpot roll-overs. A fixed percentage of money from tickets sold is allocated to the jackpot. If no one in a certain drawing hits the right number combination, money allocated to the jackpot is rolled over to the next drawing. If tickets represent dreams, it should be expected that players' demand for tickets should increase in the skewness of the return distribution of the lottery. Skewness in lotto games depends mostly on jackpot size. In fact, jackpot size has a positive and significant effect on demand for lottery tickets (see e.g., Baker et al., 2020).

One important effect of roll-overs is that the effective price of a ticket changes over time. Here, the "effective price" is consensually defined by the lottery literature as the expected loss per Dollar invested, that is, the difference between the purchase price of the ticket minus its expected return. If demand for tickets would be constant, jackpots built up from former roll-overs would lead to effective price reductions. Rational consumers therefore should react to increased jackpots by purchasing more tickets. But then, if more tickets are sold, prices rise again.

Which effect dominates? As Matheson and Grote (2004) found, the jackpot effect almost always dominates, that is the rise in expected value due to increased jackpots is higher than the decline in expected value due to increased ticket sales. The authors found that in only about 0.1% of more than 17,500 drawings, the combination of higher jackpots and higher sales led to a decline in expected value of the tickets. So, the basic result is that as jackpots grow larger, the effective prices of tickets decline.

At the same time, as jackpots grow bigger, it can be argued that the entertainment value of lotto increases, the dream gets bigger. If lotto players react rationally, they would buy more tickets at higher jackpot sizes. This is what is found in the empirical literature (see e.g., Baker et al., 2020; Scott & Gulley, 1995; Gulley & Scott, 1993; Shapira & Venezia, 1992; DeBoer, 1990).

There are other findings suggesting rational reactions of lotto players to changes in incentives. For example, Rodgers (2020) found that lotto players reacted in an informed and economically sensible way to a 10% tax on lotto winnings introduced by New Hampshire in 2009. Demand for the New Hampshire lotto fell significantly, and the largest changes were observed in border areas, suggesting increased cross-border shopping. Economically sound reactions of lotto players were also detected with respect to cross-border competition between different lotteries (see Knight & Schiff, 2012; Tosun & Skidmore, 2004).

On the other hand, rational lotto players should not be expected to be fooled by changes that have no economic meaning. In fact, they are not fooled by advertised changes to jackpots that have no economic meaning (see Matheson & Grote, 2003). In the US, jackpots are typically paid out in the form of yearly installments, usually over 20 to 30 years, rather than in the form of a lump sum. The paid-out annuity includes interest earnings. The advertised jackpot is simply the sum of the annuity payments. Prolongation of the pay-out period means that the net present value of the jackpot remains unchanged, but due to higher interest payments over the longer time span, the sum of all payments increases and the advertised jackpot increases accordingly. But as Matheson and Grote (2003) found, increases in jackpots induced by such prolongations did not increase demand for tickets. This finding suggests that gamblers are well able to differentiate between real changes in jackpots and such meaningless fake increases.

We now turn to the efficiency of betting markets. According to Fama's (1970) definitions, a market is efficient in the weak form if no abnormal returns can be generated from strategies based on past prices and a market is efficient in the semi-strong form if no abnormal returns can be generated from strategies based on publicly available information including past prices.

The literature on betting and gambling markets borrows from these efficiency definitions. For example, Thaler and Ziemba (1988) define strong efficiency as a market condition where all bets have the same expected return. If t denotes the take of the game, under strong efficiency all bets should have expected returns of $-t$.

This latter definition is equivalent to Fama's definition of semi-strong efficiency with respect to expected returns. If all bets have the same expected return, then no bet generates abnormal expected returns. However, while Fama refers to the type of information when delineating weak and semi-strong efficiency, Thaler and Ziemba (1988) refer to expected returns only irrespective of the source of information. They define the weak form of efficiency as a market condition under which no bets have positive expected returns (see also Sauer, 1998). In what follows, we adopt the definitions of Thaler and Ziemba (1988).

A well-documented bias in horse betting is the favorite-longshot bias (FLB), that is, the tendency of longshots to be overbet relative to their true winning probabilities and the favorites to be underbet. Evidence on the FLB is available over decades and across countries and continents (see e.g., Koivuranta & Korhonen, 2019; Snowberg & Wolfers, 2010; Winter & Kukuk, 2006; Jullien & Salanié, 2000; Weitzman, 1965; Griffith, 1949). While Thaler and Ziemba (1988) found slightly positive returns for bets on extreme favorites, most studies do not find evidence of positive expected returns for simply betting on favorites (see e.g., Koivuranta & Kohonen, 2019; Snowberg & Wolfers, 2010; Winter & Kukuk, 2006; Jullien & Salanié, 2000).

So, while the odds are biased, these biases are not strong enough to secure positive expected returns by simple strategies based on past odds. According to the above definitions, the FLB suggests that the horse betting market is weakly but not strongly efficient.

There are, however, also a larger number of papers documenting biases that are, or at least have been, pronounced enough to generate positive expected returns from strategies based on publicly available information. For horse racing, some opportunities for betting with positive expected returns have been found in the markets for exotic bets and the place and show bets (see Hausch & Ziemba, 1990; Ziemba & Hausch, 1985, 1987; Hausch et al., 1981).

In the NFL point spread betting market, Levitt (2004) found that bets on underdogs playing at home win more often than is required to break even. Paul and Weinbach (2012) show that in the NBA and the NFL there have been strategies of betting against the strong, public preferences for favorites, and especially for road favorites, yielding positive returns.

Pope and Peel (1989) identified bets on UK football games to be profitable if they met some conditions with respect to consensus forecasts of tipsters' and bookmakers' odds. Paul and Weinbach (2002) found that in the football betting market for totals, bets on "under" in situations where the totals suggested by bookmakers markedly exceeded the average totals across games would have yielded positive returns in the years from 1979 to 2000.

Hausch and Ziemba (1990) identified cross-track arbitrage opportunities on US horse racetracks. Paton and Vaughan Williams (2005) suggested a profitable "quasi"-arbitrage strategy in UK football spread betting. Vlastakis et al. (2009) identified arbitrage opportunities in cross-country betting in European football. Franck et al. (2013) analyzed arbitrage opportunities in the top five European soccer leagues and concluded that 19.2% of the matches offered arbitrage opportunities leading to positive expected returns. Angelini and De Angelis (2019) found bookmaker odds for bets in some European football leagues that allowed for profitable betting strategies.

Bettors show greater interest in teams that are on a winning or losing streak, making them greater favorites or greater underdogs respectively (see Paul & Weinbach, 2005). Betting against those streaks can be a profitable strategy (see Paul & Weinbach, 2005; Camerer, 1989).

There are, however, some limitations to many of these findings. One important limitation for at least some of these betting strategies is possible restrictions by supply side agents. They can and often actually do limit the amounts for each bet and might even be allowed to refuse any wager (see Paul & Weinbach, 2002). The profit opportunities of arbitrage and other betting strategies might thus already be severely limited. A second limitation is that anomalies strong enough to allow for positive expected returns might not persist for long. Sauer (1998) argues that while there are in fact profitable betting strategies, these may arise infrequently and that in some cases the pools are so small that the possible earnings hardly cover the opportunity costs of the time spent on identification. Taken together, there is some evidence that not all gambling markets are always weakly efficient, but that profit opportunities are limited.

Another strand of the empirical literature addresses the efficiency issue from perspective of the informational content of odds (see Sauer, 1998). The question here is whether odds provide unbiased probability estimates for winning the bet. For example, Elaad et al. (2020) find that bookmaker odds for English football matches to be unbiased on a market level, but not on the level of individual bookmakers.

We do not want to dive deeper into the details of this literature here, but the overall picture is that betting odds are usually a highly accurate source of sports forecasts (see e.g., Angelini & De Angelis, 2019; Štrumbelj & Sikonja, 2010). What is more, forecasts based on odds do not seem to perform worse than forecasts based on more elaborated statistical models (see Štrumbelj & Vračar, 2012; Forrest et al., 2005), although there is some work which has found the statistical models to be superior (see e.g. Reade et al., 2020).

In summary, our brief sketch of the lottery demand literature and the betting market efficiency literature suggests a reasonable level of rationality and expertise on the aggregate, that is, market level. And since evidence of the efficient use of information is not only found in bookmaker markets, but also in pari-mutuel markets, it can be concluded that gamblers and bettors display non-negligible levels of rationality. However, as one referee suggested, the degree of rationality observed at the market level in lotto markets might be due to other forces than that observed in betting markets. Whenever profit opportunities arise, a small minority of sophisticated, high stakes bettors would suffice to drive odds back to efficient levels in betting markets. It would thus be possible that the majority of bettors behaves completely irrational. Still, the minority of proficient bettors could drive the aggregate market outcomes back to efficient levels. This is likely not the case for lotto markets. Due to the extremely high takes in those markets, proficiency, and sophistication will not help to overcome the takes. It is thus highly unlikely that the market outcomes in lotto markets are due to a small proportion of proficient gamblers. It can thus be argued that the rationality evidence from lotto markets is stronger evidence for the rationality of the gambling population than the evidence from betting markets.

3.2 | Purely financial motivations

After the market perspective taken in the preceding section, we will now look at individual gamblers and bettors. It is well known that the expected returns for gambling and betting are negative in general. This has to be the case, otherwise supply-side agents like bookmakers and casinos could not survive. Nevertheless, the markets are growing, and people gamble despite their continuing losses. In what follows, we consider some possible explanations for this phenomenon, while still assuming gamblers to be rational. We start by looking at those explanations that assume gamblers to have solely financial motives.

3.2.1 | Risk love

In order to evaluate the rationality of gambling decisions, gamblers' utility functions must be known. If they are known to depend on money alone, financial gambling outcomes can be used to evaluate the rationality of the gambling decisions.

The risk love explanation is straightforward. Let us assume that homogeneous bettors play for financial reasons only and have mean-variance expected utilities $U(\mu, \sigma^2) = \mu - r\sigma^2$, where r denotes the constant coefficient of risk aversion. Option 1 is to keep the dollar. If the dollar is kept, variance is zero, expectation is $\mu = 1$, and expected utility thus becomes $U_1(\mu, \sigma^2) = 1$. Option 2 is to bet the dollar on a horse. Assume that this bet on a horse has an expected return like that of the overall market, that is, $\mu = 1 - t$, where t denotes the take, and variance $\sigma^2 > 0$. Thus $U_2(\mu, \sigma^2) = 1 - t - r \cdot \sigma^2$. The dollar is bet only if $U_2 \geq U_1$, i.e. if $1 - t - r \cdot \sigma^2 \geq 1$, or equivalently, $-r \geq t/\sigma^2$. Since $t > 0$ and $\sigma^2 > 0$ by assumption, r must be negative, that is, bettors must be risk loving to accept the gamble. Risk love can thus explain why rational individuals would gamble despite negative expected returns from their activity.

In an early empirical paper, Ali (1977) assumed homogeneous bettors with a utility of wealth (w) function of the type $u(w) = aw^b$ and estimated it as $u(w) = 1.91w^{1.1784}$, implying risk love of the bettor population. So, are gamblers really risk loving? At least in some experiments, like that of Wagenaar et al. (1984), the majority of participants indeed displayed risk-seeking behaviors.

If risk love is assumed to be the driver of betting behavior, one should also expect a negative association between expected returns and variances across different bets. Bets with higher variances should be expected to generate lower expected returns and vice versa. This variance-return pattern is exactly what characterizes the favorite-longshot bias.

This bias shows up regularly in horse race betting and has been persistently documented for decades (see Koivuranta & Korhonen, 2019; Snowberg & Wolfers, 2010; Jullien & Salanié, 2000; Vaughan Williams & Paton, 1997; Ali, 1977; Weitzman, 1965; Griffith, 1949). Empirical studies have shown that the favorite-longshot bias exists in North America (see Snyder, 1978), the UK (see Bruce & Johnson, 2000), Australia (see Tuckwell, 1983) and Germany (see Winter & Kukuk, 2006). While some exceptions have also been found (see Swidler and Shaw (1995) for one Texas racetrack, Busche (1994) for Japanese racetracks and Busche and Hall (1988) for a Hong Kong racetrack), these exceptions are based on very small samples. These deviating results may be a puzzle, but do not change the overall empirical picture.

The existence of the favorite-longshot bias is fully compatible with the risk love assumption. Indeed, as Quandt (1986) showed, the equilibrium outcome in a market with risk loving agents must be that longshots receive a percentage of the total betting volume that is higher than their winning probabilities. The opposite holds true for favorites. The result would be that expected returns on longshot bets are lower than expected returns on favorites, which exactly mirrors the observed favorite-longshot bias.

Thus, the risk love assumption can explain not only the fact that people accept negative expected return bets, but also the fact that expected returns on longshots are lower than those on favorites. Up to this point, even negative expected return gambling is fully reconcilable with rationality when utilities depend on the financial aspects of gambling only.

3.2.2 | Diversification

The risk love explanation is not the only one in which negative expected returns and rationality are reconcilable. Another explanation is investment diversification. If betting is interpreted as a purely financial transaction, a betting ticket can be interpreted as a capital asset. It should thus be possible to price the ticket as such an asset. However, if tickets are merely capital assets traded in a financial market that meets the conditions of the Capital Asset Pricing Model (CAPM), the tickets would have to display certain return characteristics.

Now, if β_A is sufficiently negative, the equilibrium expected returns of asset A will be negative. Such negative expected returns would be accepted even by risk averse agents, since such agents are not concerned with the specific risks of single assets, but only with their portfolio risk. An asset with a negative beta can be interpreted as an insurance asset, reducing the portfolio's risk, and thus making that asset more valuable for risk averse agents.

However, this line of reasoning is at odds with the evidence. This is because the outcomes of horse race bets, lottery tickets, or roulette wagers are by their nature stochastically independent of the returns of any capital market portfolio. Therefore, the betas of all these gambling investments are zero, implying that their equilibrium expected returns should equal the return of the risk-free asset r_f. If r_f is time-adjusted to the time a bet on the roulette table takes to be completed and cleared or the time a horse race takes to be run, r_f is approximately zero, since a bet often takes only a couple of minutes or even seconds to be decided. The expected returns of bets in a CAPM world would thus have to be zero. Since the true, overall expected returns are negative due to the take, these bets are not reconcilable with the diversification argument.

What is more, the risk love explanation discussed in Section 3.1.1 above is also not compatible with the CAPM. According to the CAPM, there is a positive relationship between expected returns and risk in equilibrium. This link is represented by the capital market line. Along this line, there is a constant rate of substitution between the per dollar expected yield and the per dollar standard deviation of the yield (see Pilbeam, 2018; Rui et al., 2018; Suroso et al., 2018; Copeland et al., 2005; Mossin, 1966; Sharpe, 1964). An investor choosing higher risks is thus rewarded with higher expected returns. This implies that in equilibrium, risk loving agents would not be forced to accept negative expected returns in exchange for the risk they accept. Instead, they would get paid for the risk they assume. There would thus be no reason to accept negative expected return gambles.

There is a large body of literature from the last 50 years that deals with the empirical evidence for the CAPM. Influential early studies include Friend and Blume (1970), Jensen et al. (1972), Blume and Friend (1973), Fama and MacBeth (1973), Litzenberger and Ramaswamy (1979), Gibbons (1982) and Shanken (1985). The core statements of the model are largely empirically validated in these works, but none provide complete confirmation (see Pilbeam, 2018). There are also studies which claim that the discovered weaknesses of the model explicitly invalidate most applications of the CAPM (see Fama & French, 2004) and favorably support other theories, such as Ross's (1976) Arbitrage Pricing Theory (see Kisman & Restiyanita, 2015).

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3.2.3 | Critique

We do not want to restate fully the pros and cons of the CAPM here. This is because even if the model were completely wrong, most gambling patterns that lose money would still not be reconcilable with rationality for other reasons.

For example, horse race betting as a purely financial transaction would violate other principles of rational investments as defined outside the CAPM. This is because many horse bets are stochastically dominated by other betting opportunities. For example, picking a number on a French roulette table usually dominates a bet on a longshot in horse racing, controlling for the odds (a formal proof that gamblers with mean-variance expected utilities would strictly prefer a roulette wager on a number over a longshot horse bet with the same odds is given in the appendix). There is ample evidence for violations of the dominance principle outside the gambling setting as well (see Kourouxous & Bauer, 2019).

There are other problems with the assumption of risk loving agents. We will address some of them now in a rather informal way.

First, if agents were risk loving, they would eventually accept investment opportunities with negative expected returns like horse betting. They would do so as long as the variance is high enough to compensate for the negative expected returns. But since betting opportunities are offered frequently worldwide and there is virtually no limit to the amounts that can be wagered, risk loving agents would gamble until they are bankrupt. Some people do this indeed, but the overwhelming majority of gamblers do not. The fact that they do not is also not compatible with a pure risk love explanation of gambling behavior.

Secondly, it is observed that people who gamble also buy insurance for their houses, cars, and health. By buying a lottery ticket, people spend money to increase variance. The price they pay is the negative expected return of the bet. By signing an insurance contract, people spend money to reduce variance. Again, the price they pay is the negative expected return of the contract. While betting implies risk love, signing insurance contracts implies risk aversion. So how can people be risk averse and risk loving at the same time?

One early explanation that sticks to rationality and purely financial motivation is suggested by Friedman and Savage (1948). They suggest a utility function $u(x)$ of money x that is concave for small amounts of money, becomes convex for medium amounts of money, and returns to a concave form for higher amounts of money. An example is depicted in Figure 1 below:

Now assume that an agent is currently at point A. Not signing a fire insurance contract for the house could throw him/her back to C if the house burns down. Since this would be a huge loss in utility, the agent is prepared to pay the insurance premium, which would leave him/her at a point a little to the left of A. But since the utility function is almost flat around A, the loss in utility incurred by paying the premium is low. Therefore, expected utility is increased by signing the insurance contract. On the other hand, winning the lottery would lift the agent up to point B. This would be a huge increase in utility. Again, the agent will be moved a little to the left of A by buying a ticket. But since the utility function is flat around A, the agent suffers little from doing

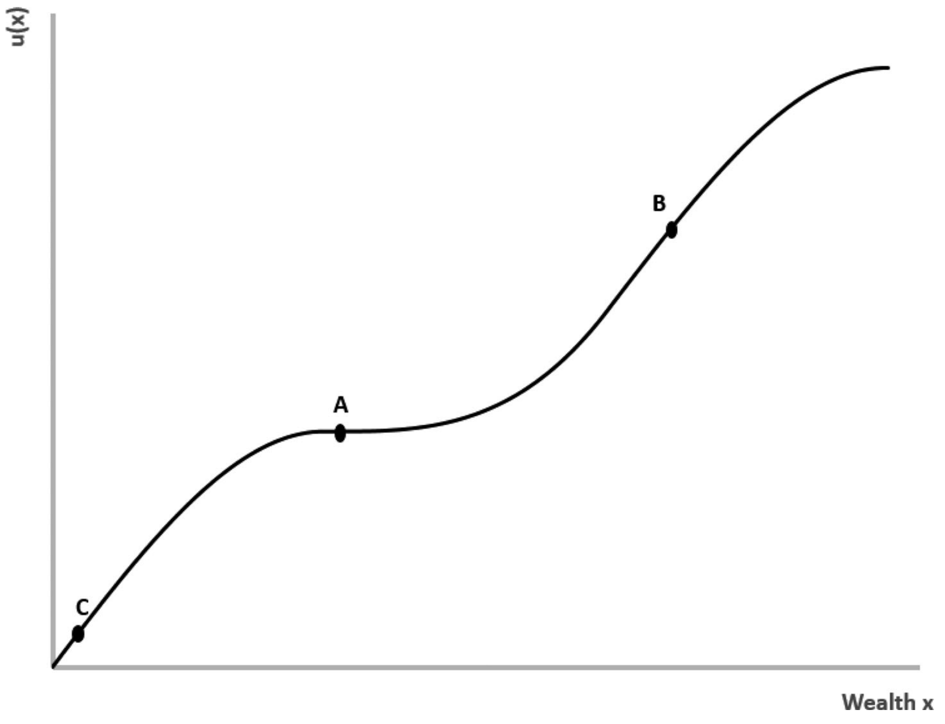

FIGURE 1 Friedman and Savage (1948) utility function

so. Thus, expected utility is again increased by buying the ticket. So, in fact, paying insurance premiums and buying lottery tickets at the same time can be explained as rational behavior of purely financially motivated agents.

If it is assumed that the above utility function is the same for all agents, then one would expect that poor people buy insurance and may gamble, while the rich only buy insurance but do not gamble. This is largely in line with the empirical evidence: poorer people spend a larger share of their income on gambling than high-income earners (see Beckert & Lutter, 2012; Clotfelter et al., 1999; Miyazaki et al., 1998; Clotfelter & Cook, 1989; Livernois, 1987; Suits, 1982).

The obvious problem with this approach is the predicted behavior of those in the middle. An agent located between A and B on the utility function would not buy insurance but would gamble until poor or rich. But this is definitely not in line with the empirical evidence. The average middle-class person does not sell their house to buy lottery tickets until they are rich or poor. Instead, the literature on problem gambling (see Section 5 below) suggests that excessive gambling is limited to a small proportion of the population (see Williams et al., 2021; Hofmarcher et al., 2020; NHS Digital, 2019; Calado & Griffiths, 2016; Francis et al., 2015; Ladouceur, 1996).

What is more, a risk love explanation using the Friedman-Savage approach runs into the same problems as it encountered above. This is because the approach still cannot explain why people play stochastically dominated horse bets when instead they could put their money on a roulette table. It also cannot explain why it's not only the poor that gamble more, but generally also those with lower socio-economic status as measured by education or employment status (see Lang & Omori, 2009; Brown et al., 1992).

Thirdly, the risk love explanation is not compatible with the fact that the typical bet is small and that over the course of a racing day or a casino evening, many bets are made by the same person.

Distributing money over a set of bets diversifies the investment risk. But if risk love is assumed, diversification of risk is not what the gambler would want. Additionally, the Friedman-Savage approach cannot explain small gambles like win bets on horses, which even if they win, do not improve the gambler's utility markedly.

Fourthly, in horse betting the financial investment is frequently accompanied by an investment of time. People spend time reading racing magazines, they analyze the past racing performances of their horses and jockeys, etc. (see Gainsbury et al., 2012; Peirson & Smith, 2010). If people had only financial motives, they would instead save their time and choose stochastically dominant roulette bets, where nothing must or can be learned (see Peirson & Smith, 2010).

3.2.4 | Conclusions

The average bettor loses money. While losing money is still reconcilable with rational investment behavior under certain assumptions, these assumptions are not sustainable for real-life gamblers. Neither the risk love explanation nor the diversification explanation adequately explains observed gambling behavior. Without considering non-financial motives, the behavior of gamblers losing money is thus not reconcilable with rationality. As already outlined in the introduction, there is one exception to this rule: A gambler placing high utility on being rich and seeing no other way to become so besides gambling, might play for example, lotto for all of his life. Even if always losing money, such a gambler might still be regarded as rational.

3.3 | Non-financial motives

If betting cannot be fully explained as rational investment behavior for most observable gambles, it may nonetheless be rational. This could be the case if at least some additional utility is derived from the non-financial aspects of gambling. For example, Nyman et al. (2008) suggest that money won in a lottery has its own charm since gamblers do not have to work for it. They thus derive an additional utility from avoiding the opportunity costs of labor. Most papers referring to non-financial motivations, however, suggest that gambling might simply generate some consumption benefits (see Eadington, 1999), for example, it might just be fun. For example, gamblers may derive direct utility from the act of anticipating elation after winning (see e.g., He et al., 2019b; Loewenstein, 1987). The act of playing for example, a lottery thus might carry a utility value in its own and part of that utility is already consumed before the draw (see Burger et al., 2020). In fact, Burger et al. (2016) found a (though small) effect of lottery participation on happiness for British recreational gamblers. Burger et al. (2020) found a positive effect for Dutch gamblers.

If anticipation is an important component of utility, then having more time for anticipation should be expected to have a positive value for at least some gamblers. This could explain why many people prefer lotto games over for example, scratch cards, since the time between buying the ticket and disillusion is longer for lotto games (see Kocher et al., 2014). The preference for delayed outcome resolution can be considered a manifestation of hedonically driven information avoidance (see Golman et al., 2017).

There also may be complementarities in consumption. For example, Golman and Loewenstein (2018) suggest that betting on a game makes the game outcome more important, which in turn adds to the utility of thinking about the game and watching it in TV. An at first sight rather strange complementary has even been found with respect to the taste of food. Rauwolf et al. (2021) found that uncertainty over financial rewards improves the taste of palatable foods.

Dickerson (1984, p.22) states that many theories of gambling "assume some form of human dissatisfaction or deprivation" concerning rationality, money, peace of mind, or others. These theories thereby overlook the sociability, challenges, creativity, and playfulness of gambling (see Binde, 2013).

3.3.1 | Indicators of consumption effects

In the following we discuss market outcomes and behaviours that suggest that gamblers interpret gambling as a consumption activity rather than as an investment activity.

It has been found that there are several consumption-related factors which significantly influence the demand for wagering and the volume of the sports betting market. For example, the quality of the teams highly impacts the number of bets made in the US (NBA, NHL, WNBA) and in Australia (variety of races and sports). Moreover, more bets are made if the scores are higher, if the games are broadcast on television, and if the teams are evenly matched–indicating that the outcome is more uncertain than in games with strong favorites facing underdogs (see Gainsbury & Russell, 2015; Paul & Weinbach, 2010, 2014, 2015). Another effect is an increase in the number of bets during holidays, especially during Christmas (see Paul & Weinbach, 2010). Similar results are provided by Paul and Weinbach (2012) for the NFL and by Humphreys et al. (2013a) for college basketball in their studies about the wagering preferences of bettors.

Thalheimer and Ali (1995) analyzed substitution effects between different gambling markets. The demand for wagering on three horse racetracks decreased significantly with the presence of a state lottery in Ohio. Paul and Weinbach (2013) and García and Rodríguez (2007) made similar observations. The former showed that in Spanish football there are substitution effects between weekend and midweek games. The latter found that bettors substitute their bets out of baseball and into American football as soon as the football seasons starts.

A related research area deals with the composition of combined bets on a pool of soccer games. Ticket demand has been found to be significantly affected by the composition of the tickets. For example, in Spain, it was found that more tickets were purchased in provinces where top teams from that region were on the coupon (see García et al., 2008; García & Rodríguez, 2007). Garcia et al. (2008) suggest that there is a consumption complementarity between betting and watching football and they attribute their finding of increased ticket demand to more excitement if people can bet on teams in their region. In China it has been shown that more attractive leagues on the coupons created higher demand (see Mao et al., 2015a, 2015b). These results contradict the assumption of purely financial motives. The authors state that bettors do not have the capability to calculate the effective prices and therefore decide according to the attractiveness of the games. This is interpreted as a clear indicator for gambling as consumption. It must be noted, however, that higher ticket sales for more proximal teams (e.g., regional teams or teams with broader media coverage) might also be due to better information availability, information needed to calculate the value of bets.

Humphreys et al. (2013b) found a home-underdog bias in the NFL, meaning that bettors prefer to bet on the best and highest scoring teams while underestimating the impact of a home-field advantage. Paul and Weinbach (2007) found this bias as well, noting that the percentage of bets increased by 16% for road favorites. Other papers supporting the home-underdog bias are Paul and Weinbach (2014, 2012, 2008), Dare and Dennis (2011) and Golec and Tamarkin (1991). Again, such an effect is not in line with the assumption of purely financial motives. The sheer number of observable games offers bettors enough information to update their beliefs, so investors should not be expected to produce such a biased pattern. On the other hand, if bettors derive joy from winning a bet that is not proportional to the amount won, it would be rational to bet on favorites since then the chances of a win and thus the number of joyful moments is maximized.

Moreover, there is also a bias in betting on totals. In total betting, bookmakers define a reference number N. It is possible to bet "over" or "under". The "over" bet is won if the total number of points scored by the competing teams in a game is higher than N. The "under" bet is won if it is below N. The observed bias is that bets on "over" have significantly lower returns than bets on "under" (see Paul & Weinbach, 2002). Additionally, it has been shown that "over" receives a much higher percentage of bets compared to "under". For example, "over" bets account for around 63% of bets in the NFL (see Paul & Weinbach, 2007) and nearly 59% in the NBA (see Paul & Weinbach, 2008). In worldwide soccer matches the imbalance is even higher, with roughly 81% of bets placed on "over" (see Flepp et al., 2016).

The consumption explanation of the "over/under" bias is quite obvious. If you bet on "under" and one or both teams score very frequently, the game may surpass the threshold number N quite early. From that point on you would watch the game knowing that your money wagered on "under" is already lost. But if you bet "over", your bet can win right up until the game is over. With an "over" bet you almost never have to watch a game with the knowledge that your money is already gone. Additionally, the entertainment value is arguably higher for "over", because cheering for high-scoring and exciting matches is much more attractive than hoping for low-scoring games (see Flepp et al., 2016; Paul & Weinbach, 2002).

Franck et al. (2011) explain that there exists a kind of loyalty bias, meaning that many bettors are affected by their sentiments and therefore do not place bets against the teams they support. Conversely, Agha and Tyler (2017) found that there are bettors who bet against their favorite teams in order to compensate the emotional losses in the case of their team being defeated with monetary gains from betting. Again, both these findings suggest that there are non-financial motives for betting.

If bettors were financially motivated investors, they would not care for any of the identified fan-oriented factors like team quality, team popularity, regional affiliation, high-scoring matches, balanced matches, uncertainty of outcome, the composition of soccer pools or whether a game is broadcast. Instead, investors would look at the prices and values of bets in order to maximize their profits (see Humphreys et al., 2013a). If, however, consumption motives are integrated into the analysis of gambling behavior, the return anomalies, which look puzzling otherwise, become easily explainable. Sports betting seems to be a complementary good to watching sporting events. Thus, the market contains recreational bettors who support and cheer for their teams and are likely to "consume" betting while watching. Hence, a greater number of bets and higher market volume are the results of fanlike behavior and greater public interest in a sporting event.

The identified substitution effects conform with this explanation. For example, American football offers no other profitable betting strategies than baseball that would justify a switch from baseball to football as soon as the season starts. Moreover, the known potential winning strategies (e.g., betting on home underdogs, see 3.1) are not commonly used by the betting majority, meaning that substitution occurs because of consumer preferences for football over baseball rather than for financial reasons (see Paul & Weinbach, 2013).

An explanation for the home-underdog bias is given by Gainsbury and Russell (2015). The authors argue that if odds would be balanced, bettors would bet evenly on each side. But this is not what is observed. In fact, there is a home-underdog bias. The authors attribute that finding to the possible influence of emotions rather than economic outcomes. However, the alternative explanation via misperceptions cannot be ruled out.

Taken together, it can be concluded that at least in sports betting, participation is partly an entertainment activity, since bettors are affected by lots of the same factors that influence fan behavior (see Paul & Weinbach, 2014; Humphreys et al., 2013a). Wagering and watching sports complement each other, and therefore bettors are consumers of sports, as opposed to investors (see Paul & Weinbach, 2011, 2013, 2014, 2015; Humphreys et al., 2013a).

3.3.2 | Self-reported gambling motives

The consumption point of view is supported by a large number of surveys, interviews, and exploratory studies about the motives of gamblers. These studies provide additional evidence for the importance of non-financial motives.

For example, social reasons have been suggested (see Sheeran & Orbell, 1999). Indeed, Garvía (2007) claims that the high demand for lottery tickets in Spain is due to the widespread tradition of sharing tickets within syndicates of friends, relatives, or colleagues. Guillén et al. (2012) found that syndicate players share tickets mainly to establish cohesive social groups and to maintain friendships, and not to maximize expected profits. Sharing tickets and the activity around playing a lottery thus create a group identity (see Beckert & Lutter, 2012). Such group phenomena have also been found in bingo hall gambling (see Bedford, 2011) and off-course betting (see Cassidy, 2010; Neal, 1998). Playing together yields shared experiences and promotes communication, while quitting the syndicate would threaten one's group membership (see Beckert & Lutter, 2012).

Wagenaar et al. (1984) report that more than half of participants considered amusement and excitement to be the major objectives of gambling. This is in line with the consumption approach. Chantal et al. (1995) found that participants who are characterized by a high degree of self-determination take part in gambling. They also explain that excitement, an opportunity to broaden their knowledge and a sense of accomplishment, as well as potential monetary rewards, were the objectives of their participants. Fang and Mowen (2009) identified excitement and escape as motives of slot gamblers; money, social contact, and self-esteem as motives of sports bettors; and money, excitement, social interaction, and self-esteem as motives of card players.

Cassidy (2012) explains in her study that contrary to the assumption of Griffiths (1999), that is, that the change from table games to machine games is a change from social gaming to asocial gaming, machine gambling is not asocial at all, but also offers great potential for collaborative gaming. She therefore confirms participating in social events as a motive for machine gambling in her study.

Gandolfo and De Bonis (2015) found that money, excitement and entertainment are the most common motives for gambling. Mulkeen et al. (2017) identified escape and relaxation, financial motivation, social interaction, and competition as the most significant factors perceived by gamblers. In a study of 4125 online gamblers, Lloyd et al. (2010) identified mood regulation, monetary rewards and enjoyment as the main motives of gamblers.

In a survey of 2796 individuals who had gambled at least once in the last 12 months, Francis et al. (2015) found fun (62%), the chance of winning big money (52%), having something to do with friends and family (48%), being sociable (40%), and excitement (38%) to be the most important motives.

The reasons offered depended on the game played. Lottery gamblers are motivated more by the chance to win money, while bingo players report gambling to be a way of socializing with friends and family (see Lam, 2007a). Electronic gaming machine players want to escape boredom and manage negative feelings (see Thomas et al., 2009; Clarke, 2005). Skill is more important in horse betting and card games. Players assume that they have control over these games and play them to win money (see Myrseth et al., 2010; Lam, 2007a).

The level of gambling activity also seems to be associated with the motives. Regular players with a diverse portfolio of gambling activities were less likely to play for financial reasons than regular players who took part in only one or two gambling activities (see Wardle et al., 2011). Lam (2007b) found that baccarat players in Macau gamble for monetary reasons, excitement, entertainment and social reasons. American senior citizens gambling in casinos were found to be driven by feelings of control, lift and escape (see Loroz, 2004). Forrest et al. (2002) found that the consumption benefit from lotteries is that buying a ticket is "buying a dream". The dream contains, for example, spending the money won or the act of quitting a job. Here, it can be argued that the dream value of lotto tickets depends more on the number of dreams than on the probabilities of one of them come true. It would thus be rational to spread ticket expenditures over a number of drawings instead of buying more tickets for one drawing. Indeed, such spreading across drawings is typically observed for lotto players (see Kocher et al., 2014). In a formal model Ely et al. (2015) analyze the effects of suspense and surprise on the entertainment utility of mystery novels, game shows, and casinos. They conclude that by betting all the money at once would deprive the gambler of an important casino experience. Since each flip of a card or spin of a wheel provides for suspense and–as the result gets known–surprise, betting all at once would forgo much of the entertainment utility. The observed pattern of gambling behavior in casinos is fully in line with this conjecture.

Beckert and Lutter (2007) suggest that lotteries especially are associated with consumption motives because the points of sale are identical or close to the points of sale of other consumer goods bought as part of people's daily routines.

While not every study identified exactly the same factors, empirical research consistently identifies five broader classes of motives for gambling. These motives are social reasons, excitement/amusement, challenge/learning/knowledge, monetary reasons, and escape/avoidance/coping (see Francis et al., 2015; Lee et al., 2007).

Overall, self-reported reasons also demonstrate that monetary reasons are not the sole or even main drivers of gambling and betting activities for most players.

3.3.3 | Combined motives

From a theoretical perspective, the integration of financial and consumption motives might yield a better understanding of gambling behavior. For example, Conlisk (1993) suggests a model of preferences that covers financial motives as well as a consumption benefit, both of which depend directly on a gamble's characteristics. This is a promising approach because even if gambling carries some consumption value on its own, it still has financial consequences that cannot be simply ignored. Rather, people should be expected to pick bets that offer a good trade-off between fun and the gamble's financial characteristics. Conlisk's (1993) paper neatly explains why people may accept only small gambles and why they prefer low probability, high return gambles over the opposite.

This approach is somewhat in the tradition of Thaler's concept of mental accounting (see Thaler, 1985). While Thaler's approach is intriguing, it still treats the fun account and the investment account as two independent black boxes. How much money goes into which account and for what reasons? What are the rules for picking a certain gamble? In this respect, Conlisk's (1993) paper is an advancement because it gives much more structure to the individual's decision problem, simultaneously evaluating a gamble's financial and non-financial consequences. It also integrates financial and non-financial motives explicitly.

3.3.4 | Conclusions

It has been shown that there are market outcomes which suggest that betting is a consumption activity for many gamblers. These outcomes are reconcilable with fan and fun-seeking behavior, and thus those outcomes that look like anomalies from a purely financial perspective might instead indicate the existence of consumption benefits. Moreover, a variety of surveys and exploratory studies underline that gamblers are driven and motivated by a set of different, non-financial motives. Consumption benefits must, therefore, be taken into account when evaluating the rationality of gambling.

On the other hand, the existence of consumption benefits does not of course imply that gambling can be regarded as rational no matter what losses are incurred. The existence of the effects documented above does not automatically prove the rationality of the behaviors driving those effects. Unless the utility function of some bettor is known, it cannot be inferred from simple observation whether their behavior is rational or not. But since there are effects that can be explained quite well by consumption benefits, it can be concluded that gambling could eventually be considered a rational endeavour despite financial losses.

3.4 | Summary

The majority of gamblers loses money. Explanations based on financial motives alone that are still reconcilable with rationality are risk love and portfolio diversification. Both explanations are not convincing, however, since they cannot explain why gamblers accept dominated wagers.

So, for gambling with negative expected returns to still be rational, there must be non-financial motives involved. There is ample evidence of effects best explained by the existence of consumption benefits. If gamblers derive utility from the activity of gambling itself, gambling might be rational even in the face of sustained losses.

As Paul and Weinbach (2013) point out, the assumption of bettors being only investors may not be valid. For the majority of gamblers, gambling might be a rational consumption activity. One problem with this conjecture, however, is that the existence of consumption benefits does not automatically turn behavior into rational behavior. Therefore, in the remainder of this paper we shall ask whether rationality may be bounded or whether even irrationality can be detected.

4 | BOUNDED RATIONALITY

If gambling is driven neither by rational investment motives nor by rational consumption considerations, it could be boundedly rational. The main assumptions of full rationality, as explained in Section 2.1, are that people have stable preferences, maximize their utility and do not suffer from a loss of control. If one of the first two of these assumptions is violated, behavior is of the bounded rationality type, if the last one is violated behavior is defined to be irrational.

A prominent approach to explain the occurrence of cognitive biases and the use of imperfect heuristics is that of dual processing. Dual process theories of the brain suggest that humans use two distinct processes/systems for decision making (for an overview see Stanovich et al., 2014). According to dual process theories, there is one system that is evolutionary older, is faster, runs automatically on an unconscious/subconscious level, needs little cognitive capacity, takes a holistic view, and strives for genetically encoded goals, while the other system has evolved later, works more slowly, relies on conscious efforts, consumes much cognitive capacity, takes an analytic view, and strives for goals of personal utility maximization (see Stanovich et al., 2014). While many different labels have been used for the two systems, in what follows we refer to System I for the former and System II for the latter as in Kahneman (2011). System I, in particular, is thought to be susceptible to cognitive biases and it uses heuristics to make decisions (see Kahnemann, 2011).

While Kahneman (2011) emphasizes that System I and System II cannot be considered separate, clear cut component groups in the brain, neuroscience nevertheless searches for neural correlates of different types of decisions. And indeed, it is found that deliberate decisions are associated with brain activation patterns that differ from the patterns observed in more automatic and/or habitualized decisions (see Lee et al., 2014; Dolan & Dayan, 2013). As opposed to orthodox economics, neuroscience and neuroeconomics explicitly acknowledge the crucial roles of automatic and emotional processing of System I (see Camerer, 2005). Deviations from rationality are no anomalies from that latter point of view, but are rather indicative of normal functioning of System I.

Evolutionary psychology (see Cosmides & Tooby, 1994a, 1994b, 1987) even highlights the evolutionary advantages of System I and its biases and heuristics. According to *error management theory*, cognitive imperfections are inevitable but evolutionary forces ensure that total costs incurred due to imperfections are minimized. Biases are not even seen as design flaws but as design features (see Haselton et al., 2005; Cosmides & Tooby, 1994b). For example, it has been suggested that positively biased confidence, that is, overconfidence, in one's own chances of success in competitions is evolutionary advantageous as long as benefits from contested resources are sufficiently large in comparison to the costs of competition (see Johnson & Fowler, 2011). The same has been suggested for other biases as well (see Haselton & Nettle, 2006). In that view, the automatic processes of System I have evolved to solve problems of evolutionary importance rather than respect logical dicta of optimal choice (see Camerer et al., 2005).

However, while some biases and the use of heuristics may indeed provide evolutionary advantages under stone age life conditions, the same heuristics and biases might not work well in modern gambling environments. Here people don't have to outsmart huge but simple-minded mammoths, but cleverly optimized slot machines that have been especially designed to exploit heuristic decision making and cognitive biases.

In contrast to the evolutionary psychology perspective, from an economic point of view, the use of heuristics and the occurrence of cognitive biases are much less favorable. Indeed, it is difficult to see how either could benefit a gambler in a commercial gambling market. While evolutionary psychology interprets some biases as a form of better-than-rational hyper rationality, the economic view interprets them as a form of less-than-rational, that is, bounded, rationality. We take this latter view in what follows.

We distinguish between rationality limits due to misjudgments or incorrect calculations of probabilities (4.1), due to biased utility forecasts (4.2), and due to other misperceptions (4.3). In 4.1 we focus on the heuristics that are responsible for particular gambling phenomena. In 4.2 we address the phenomenon of focalism, that is, the impact of biased utility forecasts. In 4.3 we address other misperceptions, for example due to cognitive limitations or inadequate information gathering. Section 4.4 is dedicated to pre-commitments sometimes used by problem gamblers, behaviors that nearly approach irrationality as gamblers use pre-commitments when becoming aware of a possible loss of control problem. A brief summary concludes the chapter (4.5).

4.1 | Erroneous probability estimations

One question that has been regularly addressed is whether or not people are able to make correct probability estimates. For example, there is evidence suggesting that the likelihoods of tail events, that is, low probability/high impact events, are especially frequently overestimated (see Barberis, 2013). An alternative explanation is that people just use shortcuts, namely heuristics, in their decision-making processes.

4.1.1 | Heuristics

The use of heuristics usually does not lead to optimal decisions, but to satisfying ones (see Simon, 1997). Nonetheless, heuristics often provide suitable solutions, and in particular, they offer cheaper solutions than elaborate approaches. Conlisk (1996) labels the costs associated with finding a solution as deliberation costs.

On the one hand, heuristics are considered quasi-rational due to the avoidance of deliberation costs, but on the other hand they are considered boundedly rational because they regularly bias people's decisions (see Kong et al., 2020; Conlisk, 1996). Tversky and Kahneman (1974) report that people mostly make use of the availability, the representativeness, or the adjustment and anchoring heuristics.

The availability heuristic "implies that what is most easily remembered affects probability judgments most strongly" (Rachlin, 1990, p.294). The representativeness heuristic means that "people expect small samples to be representative of population parameters" (Wagenaar, 1988, p.13). Finally, the phenomenon of anchoring is the effect that "different starting points yield different estimates, which are biased toward the initial values" (Tversky & Kahneman, 1974, p.1128).

Using these heuristic principles reduces the complexity of probability assessments but may lead to systematic errors. In this section we will document typical distortions due to the heuristics used by gamblers.

One possible approach to the complexity of decisions is the concept of *mental accounting* first established by Thaler (1985). Similar to financial accounting in organizations, individuals, and households are assumed to use mental accounting in order to keep their expenses under control. Individuals track their money by grouping expenditures into different categories (see Thaler, 1999), for which they have different mental accounts (see Thaler, 2008). Mahapatra et al. (2019) found significant influences of mental accounting processes on households' financial planning decisions.

According to Thaler, people segregate their incomes and outcomes into different accounts. An individual might thus have mental accounts for housing, food, clothing, and others. The individual's income will be spread across these different accounts, resulting in an explicit budget for every account (see Thaler, 1999). There may be an account for entertainment or even one for gambling, with a specific amount of money for activities belonging to this account (see Prelec & Loewenstein, 1998). That specific budget is set up in the mind before consumption, and therefore the money is mentally depreciated anyway. Furthermore, mental accounting allows people to follow different decision rules for every account.

For example, the individual will typically not risk any of his/her food account money on a gamble. But the rules of the gambling account may allow for something else. The joy derived from gambling may thus allow an investment in an activity with negative expected returns. This concept can explain why people use a specific amount of their money for gambling activities even in the face of expected losses. The link between gambling and mental accounting is well described in the work of Thaler and Ziemba (1988). Thaler assumes that accounts are not fungible, so in contrast to standard economic assumptions, there is no possibility of substitution in mental accounting (see Thaler, 1999). Heath and Soll (1996) provide evidence for restricted fungibility in different experiments. Both the violation of the fungibility assumption and the possibility of using different decision rules for different accounts show that mental accounting can best be interpreted as a boundedly rational heuristic.

A prominent judgment error is the so-called *gambler's fallacy*, also referred to as the *Monte-Carlo fallacy* (see Leonard et al., 2015), rooted in the work of Laplace (1825/1995). The literature uses two distinct definitions of the gambler's fallacy. According to one definition, the gambler's fallacy is "(...) the irrational belief that prior outcomes in a series of events affect the probability of a future outcome, even though the events in question are independent and identically distributed" (Kovic & Kristiansen, 2019, p.291). According to this definition, the gambler‘s fallacy is characterized by any belief in serial correlation of serially uncorrelated events, irrespective of the sign of correlation. Gamblers just assume dependencies which do not exist between successive events (see Fortune & Goodie, 2012; Tversky & Kahneman, 1971).

However, in what follows we assume the definition employed by Kong et al. (2020). These authors restrict the gambler's fallacy to beliefs in non-existent negative serial correlations, while they label beliefs in non-existent positive serial correlations as a *hot hand effect*.

Kahneman and Tversky (1972) present a cognitive explanation for the gambler's fallacy, which they label as representativeness heuristic. According to that heuristic, gamblers might expect the characteristics of random events to be represented not only globally, but also locally. For instance, the probabilities for black and red numbers in roulette are equal. But a gambler using the representativeness heuristic only considers local sequences of blacks and reds, which makes him/her believe that a long series of one color will be followed by one of the other color in order to restore the balance and to be consistent with the global probabilities. The gambler's fallacy is thus a result of the representativeness heuristic (see Fiedler, 2021; Wagenaar, 1988; Kahneman & Tversky, 1972). Croson and Sundali (2005) give empirical evidence for the gambler's fallacy in casinos. Other supporting evidence is given by Kong et al. (2020), Krawcyk and Rachubik (2019), Suetens et al. (2016), Xue et al. (2011), Roney and Trick (2009), Ayton and Fischer (2004), Terrell (1998), and Clotfelter and Cook (1993).

The opposite of the gambler's fallacy is the hot hand effect. The latter effect has its origin in ball sports, and Stone (2012, p.63) states that "(...) the hot hand (...) exists if the probability of a shot being made is positively correlated with the probability for the next shot". The hot hand effect is described by Gilovich et al. (1985) with respect to streaks of basketball shots. In their study, most people believed that a player who had scored several times in a row was more likely to score again with his/her next try, meaning that he/she had a "hot hand".

If the effect exists, it can be assigned to the availability heuristic (see Rachlin, 1990). Recent streaks are more easily recalled than older ones, leading to faulty overestimation of the positive correlations between consecutive performances.

Research on hot hands covers a broad range of different sports, like basketball (see Daks et al., 2018; Arkes, 2013), football (see Salaga & Brown, 2018), golf (see Stone & Arkes, 2016; Livingston, 2012), darts (see Ötting et al., 2020), baseball (see Green & Zwiebel, 2018), and horse racing (see

Wrathall et al., 2020). Most of the older evidence suggests that hot hands do not exist (see e.g., Gilovich et al., 1985), so that beliefs in hot hands are wrong. Bar-Eli et al. (2006, p.550) review the older hot hands research in sports and conclude that "most of the empirical research supports Gilovich et al.'s (1985) argument concerning the non-existence of a relationship between future success and past performance". In a later follow-up meta-analysis, Avugos et al. (2013) came to the same conclusion.

In more recent research on the hot hand effect, Miller and Sanjurjo (2018) conclude that the belief in the hot hand effect is not just a cognitive illusion. They argue that the empirical approach of Gilovich et al. (1985) and subsequent studies suffer from a selection bias. Correcting for that bias, the basic conclusions of the Gilovich et al. (1985) study are reversed, so that there can indeed be hot hands. Arkes (2013) also argues that the methods employed by many studies tend to underestimate existing hot hands. The most recent work on the hot hand in basketball concludes that hot hands really exist and that believing in their existence is no fallacy at all (see Miller & Sanjuro, 2019, 2021). Miller and Sanjuro (2019) also find that expert observers can predict which shooters are hotter. Hot hands have been observed for single players and teams (see e.g., Green & Zwiebel, 2018; Waggoner et al., 2014; Yaari & Eisenmann, 2011).

The literature on forecasting offers approaches that lead to very good forecasts of the outcomes of events. In addition to betting odds being good predictors (see Hvattum & Arntzen, 2010), there are other forecasting methods such as the Elo ratings method originally developed for and known from chess. These ratings evaluate the relative abilities of players or teams based on their past performances.

Elo ratings have been demonstrated to be among the best predictors of future outcomes of matches in, for example, tennis (see Vaughan Williams et al., 2020; Kovalchik, 2016) and soccer (see Lasek et al., 2013; Hvattum & Arntzen, 2010). Since Elo ratings have very good forecasting properties and are partially composed of recent results, it can be stated that there is a connection between future success and past performance. This is in line with the conclusions of Miller and Sanjurjo (2021, 2019, 2018). Research employing ELO ratings thus also suggests that hot hands really exist and believing in them is no mental fallacy.

Research on hot hand effects has been extended to areas beyond their sports origin. For example, there is research on hot hand effects in lotto. Suetens et al. (2016) found that players tend to bet more on numbers that have recently been drawn several times in a row. Kong et al. (2020) found the same for Southeast Asia lottery. Lotto players even seem to believe in hot hands of lotto shops. Guryan and Kearney (2008) found that lotto shops that have sold winning tickets afterwards experience significant increases in sales lasting up to 40 weeks and that the positive sales response increases with jackpot size. Since the existence of real hot hands of numbers (or shops) in lotto are impossible, these findings are clear evidence for hot hand effects in the minds of lotto players. However, not only the hot hand effect but also the gambler's fallacy has been observed in lotto play (see e.g., Kong et al., 2020; Ariyadbuddhiphongs & Phengphol, 2008; Clotfelder & Cook, 1993). Suetens et al. (2016) suggest that both fallacies may follow each other in that players avoid numbers of the last draw but if numbers show up more often then start to bet on those "hot numbers".

A question that has attracted much attention is whether betting on hot hands is profitable (see e.g., Durand et al., 2021; Byrnes & Farinella, 2016; Arkes, 2011; Paul & Weinbach, 2005; Brown & Sauer, 1993; Camerer, 1989; Gandar et al., 1988).

A rather naive strategy would be to bet on teams that have won their former matches. Such a strategy would be naive as it ignores the spreads and how they react to the recent history of games. Testing such a naive strategy, Camerer (1989) found it not to be profitable. But, as Brown and Sauer

(1993) note, whether or not hot hands are overestimated by bettors can only be evaluated when controlling for the spreads. From a betting perspective, it is only interesting whether or not there are streaks against the spreads, not whether there are streaks in winning games.

Paul et al. (2014) find significant increases in bets on NFL teams that are on winning streaks against the spreads, while betting with or against the streaks did not earn profits for bettors. Durand et al. (2021) also find bettors to overweight recent outcomes against the spread when placing their wagers. Based on individual bettor's data, Andrikogiannopoulou and Papakonstantinou (2018) find three quarters of the gamblers observed display trend-chasing behavior while none of them earns abnormal returns by doing so.

Taken together, there is some convincing evidence for the existence of hot hand biases in lotto play and point spread sports betting. In sports itself, things are different. In fact, there is recent evidence suggesting that hot hands really can exist. Believing them to exist in sports is thus not a fallacy per se.

The *illusion of control* is another phenomenon with a great impact on gambling behavior (see Lopez-Gonzalez et al., 2018). An early definition of the Illusion of control is given by Langer (1975). However, that definition is not in line anymore with contemporary definitions. Here, we follow Stark (2014), who states that illusion of control is an exaggerated belief in the impact of one owns behaviors on outcomes. In other words, people erroneously believe that they can control the occurrence of events that actually arise by chance or other factors outside their control, and thus that they have control over independent or random outcomes (see Cowley et al., 2015; Novović et al., 2012), when in fact they have no influence on outcomes or winning probabilities (see Dixon et al., 1999).

This illusion of control has been found to be greater among problem gamblers than among non-problem gamblers, meaning that this cognitive distortion can be classified as a meaningful factor in gambling behavior (see Myrseth et al., 2010). Cowley et al. (2015) explain that losing gamblers with a high illusion of control continue to gamble due to their strong but false belief in their control of the game.

Thompson et al. (1998) explain that the use of a control heuristic explains the illusion of control best. This heuristic consists of both the intention to achieve an outcome and the observed connection between the action and the requested outcome. Hence, it allows gamblers to judge how much control they have, or rather how much they seem to have. Thompson (1999) and Thompson et al. (2004) identified special situations in which illusions of control occur. The characteristics of these situations are familiarity with and a focus on success, a known desired outcome, and that people are taking action. Gambling resembles this kind of situation exactly.

For example, Chóliz (2010), Davis et al. (2000), and Koehler et al. (1994), found that bets were higher when gamblers threw the dice themselves compared to when other people threw them. The probability of winning is the same, but the act of throwing seems to promote the illusion of control. These results were also found by Dixon (2000) with roulette, while Sloof and von Siemens (2017) found support for the illusion of control in an experiment.

4.1.2 | Misperceptions

In addition to these heuristics-based phenomena, there are several other examples of how bettors miscalculate or misjudge probabilities of games.

For example, Franke (2020) and Snowberg and Wolfers (2010) found that misperceptions can explain the favorite-longshot bias better than risk love. Thaler and Ziemba (1988) suggest that the favorite-longshot bias may be the result of bettors overestimating the probability that longshots will win. This overestimation could be considered a Kahneman-Tversky type error (see Hurley & McDonough, 1995). However, this explanation seems not very convincing, since races are frequent and data availability is good, offering a sound opportunity for bettors to update their beliefs and arrive at the correct estimates (see Sauer, 1998).

Gambling decisions are often more complex than decisions of everyday life. Thus, there is a need to estimate probabilities which are not disclosed. But systematically biased estimations are observed: people overestimate small probabilities, for example, for winning a lottery, and underestimate high probabilities (see Lorkowski & Kreinovich, 2018; Kahneman, 2011). Rogers and Webley (2001) explain that lottery players seem to misunderstand the odds because in lotteries they are faced with probabilities far smaller than those they are confronted with in everyday life.

In an early paper, Wagenaar (1988) claims that most gamblers consider game properties like fairness, cheapness, or the size of prizes, but ignore probabilities completely. Beckert and Lutter (2016) found the belief in luck and fate to have a positive significant effect on lotto expenditures. A probability ignorance is documented by Rogers and Webley (2001). They also support the idea that players' main foci are skill, luck and optimism rather than probabilities and expected returns.

Insufficient knowledge about the statistical properties of games is another indicator of misperception and is moreover strongly linked to limited cognitive abilities.

Another indicator of a lack of knowledge concerning probabilities is the process of picking numbers in lotteries. There is evidence that people do not pick their numbers randomly (see Ho et al., 2019; Wang et al., 2016; Baker & McHale, 2009; Roger & Broihanne, 2007; Farrell et al., 2000; Simon, 1998). This non-random selection of numbers was termed conscious selection by Cook and Clotfelter (1993). For example, people do not pick numbers that won recently (see Ho et al., 2019; Suetens et al., 2016; Wang et al., 2016; Rogers & Webley, 2001), avoid picking strings with duplicate digits or repeating digits (see Holtgraves & Skeel, 1992), prefer to bet on numbers with a special personal significance like birthdays, age, or postal codes (see Wang et al., 2016; Chóliz, 2010; Roger & Broihanne, 2007), prefer numeric sequences, spatial patterns, the current date, the date of the draw, or the jackpot size (see Wang et al., 2016) and prefer lottery strings without neighboring numbers (see Fortune & Goodie, 2012; Haigh, 1997). In a recent study, Krawczyk and Rachubik (2019) show that when given a choice between a random sequence of numbers for a lottery ticket or a predetermined distinctive sequence of numbers (e.g. 1,2,3,4,5,6), the majority (70%) chose the random sequence. 13% were indifferent between a random number sequence and the distinctive number sequence.

Ho et al. (2019) found that the selection of numbers is influenced by the numbers players chose in the previous draw and by the winning numbers in the previous draws. Players tend to overbet numbers that have recently been drawn more frequently and avoid the winning numbers of the last draw (drop in frequency by 23.1%). An explanation for this is that these gamblers are victims of heuristics such as the gambler's fallacy and the hot hand effect, or that they believe, due to the representative heuristic, that certain numbers are drawn more often than average (see Ho et al., 2019; Suetens et al., 2016; Lien & Yuan, 2015).

Lien and Yuan (2015) and Terrell (1994) explain that this type of misconception can actually have monetary disadvantages, as picking popular numbers decreases expected returns. Roger and Broihanne (2007) and Haigh (1997) analyzed number combinations in France and the UK and found certain combinations to be more popular, indeed. Wang et al. (2016) show that in the Dutch lottery from 2010 to 2012, the most frequently chosen sequence of numbers is 4,8,15,16,23,42. This number sequence is known from the fictional TV series "Lost" as the lucky number sequence of a winner of a giant jackpot. These findings imply that picking unpopular number combinations would increase expected returns. Picking popular numbers on the other hand could thus be considered a fallacy due to bounded rationality.

However, as already outlined in Section 2, categorization of a finding along the rationality scale is not always exactly possible. So indeed, picking birthdays as lotto numbers might be considered boundedly rational because these numbers have no higher chance than any other numbers of being picked. But if many players pick birthdays, number below 32 will be overbet, reducing the returns if those numbers show up. On the other hand, there might be good reasons to pick birthdays despite their poor return characteristics. For example, birthdays are easy to remember lotto numbers (see Baker & McHale, 2009, 2011). What is more, if picking birthday numbers is just more fun, then it could also be considered a rational consumption activity. Similarly, Wang et al. (2016) and Goodman and Irwin (2006) say that many players have so much fun choosing aesthetically pleasing combinations that this compensates for the lower expected returns.

In addition, learning effects have also been found to occur among players. In the Taiwan lottery, it has been found that players first select numbers by conscious selection, but then switch to random numbers, as they seem to have learned that conscious selection leads to lower returns (see Wang & Lin, 2006). There are also gamblers that actively pick less popular numbers, thereby increasing the expected returns of their tickets (see Baker & McHale, 2009). However, these learning effects were not found in Baker and McHale's (2011) paper on the UK lottery. They conclude that "there appears to be little to no evidence of players acting rationally and learning to maximize the expected value of their ticket" (Baker & McHale, 2011, p.1082).

Nevertheless, it should be noted that it is almost impossible to get a positive expected return in lottery games, as the take-out rates are usually very high (about 50%) (see Roger & Broihanne, 2007). Even highly informed number picking should therefore not be sufficient to arrive at positive expected returns.

Gaboury and Ladouceur (1989) confirmed that gamblers mainly have erroneous perceptions during both roulette and slot machine gambling. When gamblers have success, they attribute it to their skills, but when they are losing, they attribute the losses to external factors like bad luck. Furthermore, people tend to interpret short sequences of numbers as representing the underlying distribution. These misperceptions are again the results of the representative heuristic.

Rachlin (1990) explains that people fail to determine subjective values correctly. Gamblers who structure their gambling history into strings of wins and losses will temporally discount long negative strings more than short positive ones. This may increase the subjective value of games that are objectively much worse.

Another cognitive limitation is that people have erroneous beliefs about the true chances of winning. Clark (2010) explains that in some games of chance, the player's perception of winning chances is manipulated by a near-miss effect. Unsuccessful experiences that are perceived to be very close to successful outcomes are salient events for participants. These experiences may make the gambler perceive the expected returns as positive although they are actually negative. The result is that gamblers keep on playing. Rosett (2008) offers two reasons why gamblers may expect more from a particular gamble than it actually will pay. Firstly, gamblers may misunderstand the gambles because they are too complex. Secondly, gamblers may lack the ability to use probabilities correctly.

Regular gamblers may have wrong beliefs about the chances of winning and about their own skills (see Walker, 1992). This can occur due to memory distortions, leading to a higher awareness of good memories (i.e., wins) and a lower awareness of bad memories (i.e., losses) (see Wagenaar, 1988). On the other hand, people tend to follow irrational beliefs only up to a certain point in order to limit their negative, maladaptive consequences. If irrational beliefs become too extreme, people usually avoid following them any further (see Denes-Raj & Epstein, 1994).

Finally, Griffiths (1994) suggests that slot machine gamblers, especially regular gamblers, believe that their gambling actions are much more skillful than they actually are. This can be interpreted as a cognitive limitation, because the gamblers are unaware of the genuine functionality of the machine or the randomness of wins and losses. Apart from this, it has been shown that regular gamblers do not maximize their profits, but try to maximize the time spent playing. They are aware of their losses and gamble with small stakes, but want to stay at the slot machine as long as possible. Griffiths points out that these gamblers "gamble with the money rather than for it" (Griffiths, 1994, p.363). This approach of wanting to spend time gambling could be interpreted as a kind of consumption benefit. In fact, the behavior described by Griffiths (1994) could be interpreted as a combination of rational consumption and boundedly rational calculation.

Yet another misperception by gamblers may come from unstable preferences. Thaler and Johnson (1990) found that gamblers can change their preferences concerning their participation in gambles. They labeled their finding as the *house money effect*. In their experiment, Thaler and Johnson compared a one-stage version and a two-stage version of a gamble. In the two-stage version, the participants got a safe $30 in stage one. In stage two they needed to decide whether to keep the $30 or to play a 50:50 game of chance to get $9 more or to lose $9 of the $30. In the one-stage version, the participants had to choose whether they wanted a guaranteed payment of $30 or a game with a 50% chance of getting $39 and a 50% chance of getting $21. The authors found that 77% of the gamblers were risk-seeking when there were two stages. In contrast, only 44% of the gamblers were risk-seeking in the one-stage version of the experiment (see Thaler & Johnson, 1990).

This effect has been documented by Huang and Chan (2014), Hsu and Chow (2013), Liu et al. (2010), by Frino et al. (2008) in stock markets and by Suhonen and Saastamoinen (2018) in horse race betting markets. Experimental studies supporting the house money effect are Corgnet et al. (2015), Ackert et al. (2006) and Weber and Zuchel (2005). This change of risk-attitudes indicates unstable preferences, which lead to different perceptions of identical but differently labeled situations. The house effect has also been interpreted as an instance of mental accounting (see Flepp et al., 2021; Imas, 2016). It is assumed that while playing for example. in a casino, wins, and losses so far are paper wins and losses as long as there is a chance to recoup losses. Only when leaving the casino, a paper loss is turned into a real loss and is thus transferred to another mental account. The model of Imas (2016) predicts that risk taking is higher after paper losses than after realized losses. The model of Merkle et al. (2021) predict that prior paper gains increase risk taking because subsequent losses are not subject to loss aversion. At the same time, realized gains are predicted to have no effect on risk taking. Using real casino data, Flepp et al. (2021) find that risk taking after paper gains and losses increases within a single casino visit and that the effect is more pronounced for bigger gains and losses. On the other hand, bigger realized losses from former visits decrease risk taking, while small former outcomes had no effects on risk taking. Imas (2016) provides experimental evidence showing that loss chasing occurs as long as losses are paper losses only and that an individual's flexibility in realizing their wealth positions leads to a dynamic inconsistency between planned and realized risk taking. Preferences have thus not been stable. Merkle et al. (2021) also find that subsequent risk taking is higher as long as long as outcomes are not realized. Loss chasing is also found for poker players after paper losses (see Smith et al., 2009).

4.2 | Focalism

A possible cognitive limitation that has not yet been addressed by gambling research–as far as we know–is the limitation in the ability of gamblers to correctly forecast the utility of gambling outcomes themselves. If buying a lottery ticket is buying a dream, that dream might turn out to be much less attractive than was envisioned.

The vast majority of explanations of boundedly rational gambling assume some kind of misperceptions of the gamble itself. In terms of the expected utility concept, it's the probabilities that are misperceived, not the utilities. However, it may also be the utilities that are misperceived. Focalism describes the phenomenon that humans tend to focus on one event and neglect to consider the effects of the surrounding context on their emotions (see Lench et al., 2011), or that they tend to neglect other events that will also happen (see Wilson & Gilbert, 2005).

For example, Kahneman et al. (2006) found that people with above average incomes are barely happier than others and do not spend more time doing particularly enjoyable activities. The authors argue that people exaggerate the contribution of income to happiness because they focus on conventional achievements when building their expectations. In line with that argument, a review by Dolan et al. (2008) found that subjective well-being is more affected by poor health, separation, unemployment, and lack of social contact than by money. On the other hand, income, and relative income, that is, income compared to the income of a relevant peer group, are also typically found to have positive impacts on diverse measures of well-being, but with diminishing marginal effects (see Clark, 2018).

People base many decisions on affective forecasts, that is, predictions about their emotional reactions to future events (see Wilson & Gilbert, 2005). In doing so, they typically exaggerate the emotional impact of future events (see Lench et al., 2011). Generally, the ability to foresee all the consequences of future events is limited (see Gilbert, 2006). It has been shown that people are not even able to correctly forecast the degree of happiness they will experience a few days after their favorite football team has played against their arch rival (see Wilson et al., 2000). So, they presumably are not able to estimate their degree of happiness after life-changing events like winning big in a lottery. In fact, Nisslé and Bschor (2002) present two clinical case studies where the shock of winning led to depression and hospitalization. The act of buying a ticket may be buying a dream, but winning the lottery might then turn out to be a nightmare.

However, the typical winner seems to experience something in-between a dream come true and a nightmare. Many of them carry on their lives as before with less impact than expected. Kaplan (1987) found that only 10 out of 900 winners immediately spent all their winnings in a hedonistic, often alcoholic spree. Winners' spending typically concentrates on children and relatives, investments in stocks, bonds, and real estate, and in liquidating debts (see Kaplan, 1987), while typical daily expenditures are not affected (see Kuhn et al., 2011).

Eckblad and von der Lippe (1994) point out that there were remarkably few changes in lifestyle and activities and that there was more responsibility than pleasure in the winners' reactions in their Norwegian sample. Larsson (2011) found that winners are cautious about realizing dreams of becoming someone else somewhere else. In his sample, winners essentially tried to stay the same, a finding corroborated by Hedenus (2011). While some studies found huge impacts of high lottery winnings on employment decisions (see Kaplan, 1978; Smith & Razzell, 1975), others found only moderate effects (see Cesarini et al., 2017; Furaker & Hedenus, 2009; Arvey et al., 2004).

Research on focalism has identified an impact bias, whereby people overestimate the intensity and duration of their emotional reactions to future events (see Wilson & Gilbert, 2005). In fact, a number of papers found only minor effects of lotto winnings on well-being and happiness (see e.g., Cesarini et al., 2016; Kuhn et al., 2011; Gardner & Oswald, 2007; Brickman et al., 1978). For example, Brickman et al. (1978) found that lottery winners are no happier than controls, and even report less enjoyment of mundane, daily pleasures. Winners often considered good health and close social relationships more satisfying than large cash surpluses.

However, there are diverging results as well. Oswald and Winkelmann (2019) found some positive effects, as did Apouey and Clark (2015), who found a significant positive correlation between lottery winnings and overall life satisfaction. The positive effect on overall life satisfaction has even been found to persist for over a decade (see Lindquist et al., 2020). At the same time, Lindquist et al. (2020), like Brickman et al. (1978), also found little effect on happiness, suggesting that life satisfaction and happiness are indeed highly distinct concepts with which to evaluate life, as suggested by Kahneman et al. (2006). Winkelman et al. (2010) found improved financial satisfaction for winners of very large prizes, although the improvement set in only about two years after the win. The authors attribute this lag to the time winners need to persuade themselves that they deserve the money before they can enjoy their windfalls.

In a more recent paper, Kim and Oswald (2019) were able to control for the amount of money spent on tickets. They argue that those who spent a lot on tickets feel less happy when winning since they invested more compared to those who spent less in the first place. Since more winners will come from the group of heavy spenders, estimates of the total emotional effects of winnings tend to be biased downwards. Adjusting for this, Kim and Oswald (2019) found statistically positive effects of winnings on well-being. The effect of winnings on life satisfaction are especially pronounced for big wins (see Oswald & Winkelmann, 2019).

The evidence for the impact of winning on health is mixed. While there is ample evidence that higher socio-economic status is associated with better health, the causal interpretation of this is open to question (see e.g., Apouey & Clark, 2015; Lindahl, 2005). Lottery winnings are an almost ideal experiment to test the direction of causality, since wins can be assumed to be unexpected and purely exogenous. Lindahl (2005) found general health to improve and mortality to decline after significant winnings. Gardner and Oswald (2007) found that lottery winnings have a significantly positive impact on mental health. Using a broader health measure, Apouey and Clark (2015) also found that lottery winnings improve mental health but at the same time reduce physical health. The latter is due to an increase in risky behaviors: winners start to smoke more and engage more in social drinking, and the probability of more frequent social drinking depends positively on the amount of money won. Apouey and Clark (2015) concluded that the net effect of improved mental health and the increase in risky behaviors is negligible.

So far, research suggests that winning the lottery has a rather limited impact on the lives of winners. While winning somewhat improves the life of the average winner, it does not usually seem to lead to extreme happiness. A limitation of most of the studies cited above is that they cover mostly moderate winnings. Brickman et al. (1978) covered some big winners, but seven out of 22 winners won $100,00 or less. More than 50% of Kaplan's (1987) sample had winnings of below $300,000. It is thus still an open question whether sudden, overwhelming wealth corrupts people or makes them terribly happy (see Eckblad & von der Lippe, 1994).

However, the anecdotal TV and newspaper evidence on dreams turned sour (see e.g., Grauschopf, 2019; Witt, 2018; Chan, 2016) seems to play an important role in the building of self-conceptions of lottery winners. As Hedenus (2011) finds, narratives about squandering winners play an important role as negative, to-avoid blueprints of behavior for many lotto winners.

A limitation that has not yet been adequately addressed in the literature so far is a possible happiness or life satisfaction selection bias. If those who gamble heavily are doing so because they are extremely unhappy with their current financial status, then the gain in happiness of these people after winning will lead to overestimations of the modal gain in happiness of winning gamblers. The positive effects documented in the studies cited above might therefore be biased upwards.

In conclusion, bounded rationality might not only be rooted in biased probability estimates when calculating expected utility. Instead, the assumed utilities themselves might also be wrong. The estimated effects of winnings on utility might be exaggerated.

4.3 | Misinformation

In the following, we will consider the possibility that bettors' calculations and estimates of probabilities and future utility values may be correct, but the way they select their bets is not completely rational. Under full rationality, gamblers would compare all alternatives and evaluate them by their expected utilities. Gainsbury and Russell (2015) found that about 45% of all bets are placed on simple wins, while exotics attracted 16.57%, each way bets 15.81%, and all other types taken together about 23%. They interpret this finding as an indication that bettors prefer simple bets. This could indicate that many bettors are lazy in their choice of bets and thus avoid the necessity of more complicated calculations.

In another study, Gainsbury et al. (2012) showed that there is a difference between the amount of money lost per Dollar wagered by more frequent bettors and the per Dollar loss of less frequent bettors. They concluded that more frequent bettors take more time to search for information or to compare alternatives, and thus pick odds in a more successful way, whereas less frequent bettors tend to be less concerned and thus do not spend "enough" time on information search. Fully rational agents would search for every piece of information available and compare all known alternatives. The more frequent bettors act more in accordance with rationality, but the more casual bettors do not, implying that they behave boundedly rationally due to inadequate information procurement.

Griffiths (1994) showed that people in casinos are influenced by the wins of other players. Slot machines are often placed directly next to each other, so that the sound of a winning machine is definitely observed by all neighboring players. Due to the loudness, wins seem to be commonplace, but in fact they are rare. Similarly, winners of lotteries or the like are often displayed in the media, whereas all the losers remain unnoticed. Thus, players are confronted with biased reports about the frequency of wins and losses that may lead them overestimate chances of winning and to continue playing.

Neal (1998) analyzed gamblers' behavior in horse race betting shops. He differentiated between regular gamblers, who consider gambling a leisure activity, professionals, who live from gambling, and addicted, self-destructive gamblers. Neal (1998) points out that there exist a small number of professional gamblers who put huge efforts into their betting processes (see Rosecrance, 1988; Saunders & Turner, 1987; Bird & Manners, 1985; cited from Neal, 1998). Nevertheless, the regulars are by far the largest group and show a lack of information, as well as limitations in the accuracy of their assessments of the relative influence of particular factors on the results of races. Only a few of all the relevant factors are considered by regular bettors (see Neal, 1998). This may indicate that the small group of professionals might act close to full rationality, but that the overwhelming majority, the regulars, behave at most in a boundedly rational way.

4.4 | Commitment strategies

The last aspect to be addressed here is the use of commitment strategies. Ladouceur et al. (2012) and Brevers et al. (2016) suggest that gamblers can use pre-commitment measures to resist short-term temptations. Pre-commitment systems refer to the ability to anticipate failures of self-control and can thus be used to resist the temptation to gamble.

Gambling decisions, like all others, depend on higher order thought processes, referred to as executive functions, made of "cool" cognitive and "hot" emotional components (see Brock et al., 2009). Core executive functions are inhibition (i.e., resisting temptations and impulses), interference control (i.e., selective attention), working memory, and cognitive flexibility (see Diamond, 2013). Problem gamblers display impairments of their executive functions (see e.g., Mallorqui-Bagué et al., 2018; Ochoa et al., 2013; Ledgerwood et al., 2012; Marazziti et al., 2008). Neuroscientific research shows impaired activity in the pre-frontal cortex of problem gamblers (see Moccia et al., 2017) and brain activation patterns different from healthy controls (see Quaglieri et al., 2020). Loss chasing and a failure to inhibit impulsivity is regularly found in problem gamblers (see Zhang & Clark, 2020; Navas et al., 2017).

Some problem gamblers, aware of their vulnerability to their “hot” impulsive urges, are reported to use a variety of explicit strategies in order to reduce the negative effects of their gambling (see Moore et al., 2012). Identified strategies include setting time limits, setting expenditure limits, focusing on other activities, or even destroying credit cards (see Hing et al., 2016a). The fact that some gamblers with gambling problems are able to make use of these self-management strategies implies that they have maintained enough self-control to protect themselves. Currie et al. (2020) found, in their study of 10,054 Canadian adult gamblers, that the number of self-control strategies used was positively correlated with the problem gambling severity. Self-control strategies included setting spending limits, tracking money spent, or limiting alcohol consumption. The majority succeeded in implementing the self-control strategies, but about 45% of the gamblers failed to do so.

Brevers et al. (2016) conclude that although pre-commitment does not moderate risk-taking, it is able to influence self-control. Pre-commitments are protective tools, especially for gamblers who are prone to a lack of self-control (see Ladouceur et al., 2012). Strohäker (2019) finds for a sample of gambling arcade visitors that those using self-commitments display less problematic gambling behaviors. The results hold after controlling for self-efficacy traits.

An extreme form of a self-commitment is self-exclusion where gamblers close accounts or authorize venue staff to deny them entry. Ladouceur et al. (2017) review, among other aspects, the literature on antecedents and consequences of self-exclusion, where self-exclusion is mainly found to have positive consequences for problem gamblers.

Since we have chosen loss of control as the criterion characterizing irrationality, those gamblers whose explicit objective is not to become loss of control victims could be labeled as boundedly irrational, which can be regarded as a bridging concept between bounded rationality and irrationality. A gambler displaying boundedly (ir)rational behavior still has enough self-control to keep their losses from gambling within acceptable limits.

Commitments from gamblers are usually accompanied by legal gambling restrictions and responsible gambling policies and measures taken by firms in the industry. Responsible Gambling initiatives documented in the literature typically use one or more of the following five measures. (1) identifying problem gamblers by using actual behaviors, (2) setting gambling limits, (3) self-exclusion programs, (4) venue staff responding to patron problem gambling, and (5) specific responsible gambling features (see Ladouceur et al., 2017).

A review of Tanner et al. (2017) suggests that self-appraisal pop-up messages, $1 maximum bet restrictions, removal of large note acceptors and ATMs, reduced operating hours, and smoking bans most effectively reduce gambling time and expenditure. However, as the authors point out, there are concerns over the quality of studies reviewed; results should thus be considered preliminary only. In another review, Delfabbro and King (2021) conclude that mandatory systems to limit time and spending have indeed potential benefits. On the other hand, there is also critique on the effectiveness of industry codes of conduct. For example, Rintoul et al. (2017) find that in a sample of Australian electronic gambling machine venues, venues mainly failed to respond to signs of gambling problems and instead encouraged continued gambling. Such failures to address gambling problems are not limited to firms in the business, governments may also fail. For example, the Northern Territory in Australia allowed note acceptors in hotels and clubs in 2013 with a load limit of $1000 and in 2015 lifted the caps on the number of allowable electronic gambling machines in those venues. As a consequence, real user losses increased significantly (see Stevens & Livingstone, 2019). On the opposite side of the coin, Mikhed et al. (2017) found that legislation to remove slot machines from bars reduced the number of personal bankruptcies of close neighbors within 100 m.

4.5 | Summary

The previous sections present evidence on possible violations of full rationality. Many gamblers make wrong calculations of probabilities or even ignore them completely. They use heuristics to make their decisions instead of optimizing. They also have cognitive limitations in statistics and probability theory and do not try to search for the best options, but simply settle for a satisfactory option.

However, while there is evidence of bounded rationality, in most instances it is not obvious what kind of deviation from the rationality assumption is at work. It is possible that several different heuristics or several failures can occur in one and the same gamble (see Wagenaar, 1988).

It can be concluded that many people's gambling behavior can best be understood by assuming bounded rationality. It may be that people accept financial losses that are not compensated for consumption or other non-financial benefits due to erroneous perceptions or calculations. However, since the studies which focused on the limits of rationality do not control for consumption benefits, our above conjecture is somewhat speculative.

5 | IRRATIONALITY

According to the working definition from Section 2.3, behavior is considered irrational if it suffers from a loss of control. The empirical evidence, however, refers to what is called problem gambling instead of referring directly to loss of control. This is especially true for prevalence studies. The instruments used to measure the severity of gambling problems are typically multi-item questionnaires that address not only loss of control issues, but also severity of outcomes and other gambling related issues. Accordingly, a higher score on a problem gambling index does not automatically imply a higher score on the loss of control sub-index.

On the other hand, loss of control is often considered a decisive criterion for whether or not players are classified as problem gamblers (see Myrseth & Notelaers, 2017; James et al., 2016; Romanczuk-Seiferth et al., 2014; Bjerg, 2010). Blaszczynski and Nower (2002, p.488) explain that “the defining feature of a problem gambler is not only the emergence of negative consequences but also the presence of a subjective sense of impaired control”.

In a study with Canadian students, Bergen et al. (2012) show that problem gamblers report lower trait self-control than do non-problem gamblers. It should be noted that the determination of self-control was self-assessed by the participants in one part of the study and determined by means of tasks that have nothing to do with gambling in another part. The results are confirmed in a replication study by Bergen et al. (2014) with students and community participants who completed the PGSI. In a cross-sectional study with Chinese teenagers Cheung (2014) finds that those with low self-control are approximately 1.2–1.4 times more likely to be at-risk gamblers or likely pathological gamblers. Russell et al. (2019b) find for sports betting that lower self-control is a significant risk factor for problem gambling. Moreover, lower self-control is also reflected in more impulsive betting (see Hing et al., 2016b, 2018) and in greater impulsivity in general (see Russell et al., 2019a). Both have been linked to problem gambling (see Russel et al., 2019b).

In what follows, we will therefore treat identified (high) problem gamblers as those who suffer from a loss of control, although we have no information on the loss of control sub-indices for these gamblers. We then interpret (high) problem gambling as indicative of irrationality.

5.1 | Problem gambling, outcomes, and prevalence

While the overwhelming majority of gamblers display a controlled gambling pattern with limited amounts of money at risk, there is also a fraction of the gambling population with severe problems.

Negative consequences of gambling include divorce, job loss, debt, imprisonment (see Park et al., 2010) or reduced quality of life in general (see Ioannidis et al., 2019). Several studies show that debt is a highly relevant problem for problem gamblers (see Shannon et al., 2017; Thon et al., 2014; Cowlishaw & Kessler, 2016). Park et al. (2010) and Kim et al. (2006) confirm that many problem and pathological gamblers face huge financial losses or even bankruptcy. In some early studies the proportion of pathological gamblers who declared bankruptcy varies between 18.2% (see Breen & Zimmermann, 2002), 19.2% (see Gerstein et al., 1999) and 22.8% (see Breen, 2004). Komoto (2014) finds a share of 10.6% in his study. In their recent meta-analysis, Allami et al. (2021) conclude that bankruptcy filing is statistically significant but with small effects. They find that bankruptcy rates are two to four times higher for problem gamblers.

Problem gambling is also associated with suicide, suicide attempts, and suicidal thoughts. Ladouceur (1996) reports that 26.8% of pathological, high problem gamblers and 8.2% of problem gamblers have attempted suicide, in contrast to 7.2% of non-problem gamblers. In the 2000s, the proportion of problem gamblers under treatment who attempted suicide varied between 17%−39.5% (see Hodgins et al., 2006; Ledgerwood et al., 2005; Kausch, 2003; Petry & Kiluk, 2002). In his Japanese sample, Komoto (2014) found a prevalence rate of suicide attempts of 12.1% among pathological gamblers undergoing treatment. Guillou-Landreat et al. (2016) found that pathological gamblers are 3.4 times more likely to attempt suicide compared to the general population. Other studies confirming the association of increased suicide attempts with problem gamblers are Wardle and McManus (2021), Wardle et al. (2020), George et al. (2016) and Thon et al. (2014). Sundqvist and Wennberg (2021) recently analysed the subclinical level of problem gambling and found a significant association between problem gambling and suicidal ideation, although no causality could be established.

Prevalence studies document significant variations in the prevalence of problem gambling across different countries. The most commonly used screening methods are the SOGS (see Lesieur & Blume, 1987) and the PSGI (see Wynne, 2003; Ferris & Wynne, 2001).

In a sample of 2796 Australian individuals who had gambled at least once over the past 12 months, slightly fewer than 1800 were regular gamblers. A problem score could be computed for 1719 of these. 85% were identified as "non-problem gamblers", 10.3% as "low-risk gamblers", 3.4% as "moderate-risk gamblers" and 1.3% as "problem gamblers" (see Francis et al., 2015).

Hofmarcher et al. (2020) show with data from the Public Health Agency of Sweden and the PGSI screening tool that 95.8% of the population are non-problem gamblers, 2.9% are low-risk gamblers, 0.7% are moderate-risk gamblers and 0.6% are problem gamblers.

The Health Survey for England 2018 includes data on the prevalence of gambling in a sample of 8178 adults that represents the whole population. 54% of adults participated in some form of gambling in 2018. Using the PSGI screening tool, 0.4% of adults were identified as problem gamblers, and 3.6% were identified as at-risk gamblers (low + moderate risk) (see NHS Digital, 2019).

Williams et al. (2021) show in their study, which uses data from Canada from 2018 that 33.8% of the 23,952 adults surveyed were non-gamblers. 62.9% were non-problem gamblers, 2.7% were at-risk gamblers and 0.6% were problem gamblers.

Calado and Griffiths (2016) provide a good overview of worldwide problem gambling prevalence rates between 2000 and 2015. Based on 69 studies using different screening methods, they show that there is variation in problem gambling rates between 0.12% and 5.8% worldwide and between 0.12% and 3.4% in Europe.

NHS Digital (2019) and Williams (2021) explicitly report the percentages of non-gamblers. From those figures it can be calculated that something between 0.4%/54% = 0.74% (NHS Digital, 2019) or 0.6%/66.2% = 0,91% (Williams et al., 2021) of the gambler population are (high risk) problem gamblers and are thus classified as irrational gamblers. A comparative figure of 0.84% can be computed for the Australian sample of Francis et al. (2015).

If it is assumed that about 60% of the surveyed populations gamble, the estimates of 0,12% to 5.8% of the overall populations being problem gamblers imply that something between 0.2% and a little less than 10% of all gamblers are problem gamblers.

5.2 | Explanations

The factors driving problem gambling are manifold and diverse. Buth et al. (2017) provide a review of empirically significant risk factors. They identify factor such as genetic variables, a lower level of education, a below average social status and being male as risk factors. Richard et al. (2020) identify high sensation seeking, emotion-focused coping styles, suppressive, and reactive depressive symptoms, attention problems, delinquency, and conduct problems as risk factors.

There are, however, also economic explanations for why a loss of control problem might arise. One example is Barberis (2012), who models the behavior of a casino gambler making decisions based on valuations derived from cumulative prospect theory (see Tversky & Kahneman, 1992). According to that theory, individuals do not use objective probabilities in their calculations but weighted ones. The weightings given to low probability events are disproportionally high, and the likelihood of low probability events is thus exaggerated. Barberis (2012) analyses the myopic behavior of a casino gambler who enters the casino with the plan to leave the casino when faced with losses and to stay while winning. Since the low probability of having a positive streak is overestimated, the gambler perceives his/her plan as one with positive expected value. But as Barberis (2012) demonstrates, there are many parameter constellations that lead to time inconsistencies. For many of these, the gambler will not stick to his/her initial plan. While playing, the gambler updates his/her beliefs about the chances of winning and losing. These updates eventually lead to less biased probability estimates. Eventually, the gambler will completely "forget" his/her initial plan and gamble on in the face of losses while leaving the casino early in the case of winnings, the exact reversal of his/her initial plan. Barberis (2012) shows that under these circumstances, a losing gambler will gamble until the casino closes. This will happen if the gambler is naive and unaware of the time inconsistency he/she faces. If he/she is aware of this time inconsistency, his/her behavior will depend on the availability of commitment devices. If he/she can use credible commitments like going to the casino carrying only cash, he/she will leave. If no such devices are available, he/she will completely refrain from going at all.

He et al. (2019a) generalized Barberis' casino model to an infinite time horizon and got results consistent with Barberis (2012).

Economists typically treat money as a tool, something that has no value on its own but derives value only from its purchasing power (see Furnham & Argyle, 1998). However, beliefs about money and the value of money vary across individuals (see Mitchell & Mickel, 1999). Lostutter et al. (2019) found that college students who have high power/prestige or anxiety attitudes towards money face more gambling problems. Problem gamblers report in various studies that money or financial rewards are one of their most important motives for gambling (see Mulkeen et al., 2017; Coman et al., 1997). Money, it seems, is more important to them as it is for others.

The neuroeconomics approach (see e.g. Camerer et al., 2004, 2005; Glimcher, 2003) looks at neural correlates of decisions (see Huettel et al., 2006; Platt, 2002). Research in this tradition tries to identify the neural processes underlying economic variables like probability, risk, ambiguity and utility (see Pearson et al., 2014).

From the neuroeconomic perspective, the fact that gambling may lead to a loss of control problem comes as no surprise. Kishida et al. (2010) point out that the structure of gambles is not arbitrary, but that games have coevolved over thousands of years around the human nervous system. Those games that survive or that are successfully introduced are those with design features that exactly exploit the frailties in human decision-making systems while also maintaining the human desire to play them (see Kishida et al., 2010). Clark (2010) analyzed brain functions related to cognitive biases and concluded that the brain's reward system is especially susceptible to cognitive distortions associated with gambling.

Interestingly, many of the documented problems in human decision making have also been found in animal decision making, suggesting that neural circuitries are adapted to the challenges all species face, that is, foraging, survival, and reproduction (see Camerer et al., 2004). At the same time, this finding suggests that successful games are those whose characteristics mimic evolutionarily important challenges.

Lea and Webley (2006) suggest that money might have some value on its own. For example, it has been found that monetary incentives stimulate immediate cortical reward pathways (see Ross et al., 2008). Lea and Webley (2006) argue that money therefore might not only be a tool, but might also become a drug. In this latter view, repetitive gambling is driven by the need to stimulate brain reward centers to achieve elevated states of subjective excitement (see Blaszczynski & Nower, 2010). The repeated unpredictability of gambling leads to arousal and excitement that mimics natural rewards at the neurochemical level (see Ross et al., 2008). In this view, gambling has a reinforcing value in its own right and is not just a coping mechanism for otherwise unresolved problems (see Blaszczynski & Nower, 2010; Ross, 2010).

Other findings from neuroscience and neuroeconomics are that a couple of brain injuries tend to contribute to loss of control problems. For example, injuries to the cortex and the amygdala have been found to impair decisions.

Lesions of the orbitofrontal cortex correlate with lack of sensitivity to risk and ambiguity (see Hsu et al., 2005). Lesions of the prefrontal cortex led to deficits in decision making in the Iowa Gambling Task (see Ouerchefani et al., 2017, 2019).

The amygdala has been shown to be especially important in decision making because it associates a stimulus with its emotional value, triggering autonomic responses to emotional stimuli like monetary rewards or punishments (see Gupta et al., 2011). It has been shown that the structure of the amygdala is correlated with risk tolerance (see Jung et al., 2018). DeMartino et al. (2010) showed that subjects with bilateral amygdala damage displayed a dramatic reduction in loss aversion in monetary gambles.

5.3 | Summary

We defined irrational behaviours as those that suffer from a loss of control. Loss of control has been identified as the main driver of problem and pathological gambling.

The literature offers a wide spectrum of explanations for why a loss of control might occur. These explanations cover biological, psychological, and medical factors, as well as economic explanations.

The prevalence rates of gambling disorders vary substantially across the world, with rates ranging from almost zero up to around 6% of the overall populations and something between almost zero and 10% of the gambler populations. We thus conclude that there is some irrationality in gambling, but that it is limited to a small share of the gambler population.

6 | CONCLUSION

We reviewed empirical evidence on gambling activities in order to answer the question of why people gamble and why most of them continue to do so despite their sustained losses. The evidence suggests that there is no one-fits-all answer.

We organized this paper according to the three concepts of rationality, bounded rationality and irrationality. We used the standard definitions of rationality and bounded rationality found in economics and defined irrational behaviors as those that suffer from a loss of control.

There is evidence on gamblers that make money from gambling by using sophisticated strategies, using insider information or by manipulation. These gamblers can be considered rational investors. Additionally, market outcomes in gambling and betting markets suggest that there must be high levels of sophistication and sound economic reasoning behind many gamblers' decisions. For example, odds are very good predictors of sporting event outcomes and demand for lottery tickets typically reacts in a predictable and economically sound way to changes in incentives created in lottery markets. At the market level, high degrees of rationality can thus be detected.

We then addressed the question of whether there could also be solely financially motivated gamblers who lose money but who may still be regarded as rational agents. While at first sight risk love or portfolio diversification arguments could offer explanations, it was concluded that these answers are not convincing. This is because neither the risk love nor the diversification arguments can explain why gamblers accept dominated bets and wagers. So, if purely financial motives are assumed, only those gamblers that make money can be labeled rational. One exception would be those gamblers that derive high utility from being rich but see no other way than gambling to accumulate enough wealth.

When the assumption of purely financial motives is relaxed to allow for consumption benefits, gambling may be rational despite sustained losses. There is ample evidence that consumption benefits do indeed matter. Therefore, gambling might be much more rational than it looks from a purely financial point of view. Empirical evidence on consumption benefits is corroborated by self-reports on gambling motives, which stress that non-financial motives like fun, social reasons, and sensation-seeking are important for many gamblers. While the existence of consumption benefits does not prove the rationality of gamblers per se, it casts heavy doubt on claims that gambling is automatically irrational just because gamblers lose money.

We then discussed bounded rationality. There is evidence on a variety of deviations from rationality, for example the use of heuristics, the use of biased probability estimates, focalism, and the illusion of control, to name only a few. The evidence suggests that the majority of gamblers might be located somewhere between boundedly rational investors and rational consumers deriving non-financial benefits from their activities.

Located at the opposite end of the rationality scale is irrationality, defined by a loss of control. Loss of control is the single most important driver of problem gambling. The evidence suggests that a small proportion of the gambler population is affected and that there is significant cross-country variation in prevalence rates across the globe.

Our survey covers a broad collection of empirical evidence which suggests that there is no such thing as the representative gambler who neatly represents a whole gambler population. Instead, there are highly differentiated agents involved in gambling, ranging from quasi-rational gamblers making fortunes to definitively irrational gamblers gambling their lives away. The degrees of rationality involved in gambling vary considerably across the gambler population, as do their motives for taking part in the act of gambling.

DATA AVAILABILITY STATEMENT

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

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ORCID

Robin Maximilian Stetzka https://orcid.org/0000-0003-0648-7203

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APPENDIX

In Section 3.2.3 we argued that neither the risk love nor the diversification arguments can fully explain observed betting and gambling behaviors. This is because some of the betting audience accept dominated bets. Here, we will briefly demonstrate for just one example that agents with mean-variance expected utilities will strictly prefer a roulette wager on a number over a horse bet on a longshot, controlling for the odds. If you pick a number on a French roulette table, your profit is 35 if you hit and −1 otherwise. The odds for number k on the table are thus

$$O_{k,FR} = 35$$

The subscript FR indicates French roulette. The probability that a bet on any number k wins is $1/37 \approx 0.027$. The expected profit of a \$1 bet thus becomes

$$E\left(R_{k,FR}\right) \approx 0.027 \cdot 35 + (1 - 0.027)(-1) \approx -0.027$$

The variance is

$$\sigma_{k,FR}^{2} = 0.027 \cdot 35^{2} + (1 - 0.027)(-1)^{2} - (-0.027)^{2} \approx 34.05$$

Now assume that there is a horse k with a winning probability of $p_k = 0.027$. The expected profit of a bet on that horse is

$$E\left(R_k\right) = 0.027\frac{(1-t)}{W_k} - 1$$

Since a horse with a winning probability of 0.027 is a longshot, the observed favourite-longshot bias dictates that $W_k \geq 0.027$, and thus $E(R_k) \leq -t$. Let's just assume $t = 0.15$, implying $E(R_k) \leq -0.15$.

The variance of that bet is

$$\sigma_k^2 = p_k\left(1 - p_k\right)\frac{(1-t)^2}{W_k^2}$$

$$= 0.027\,(1 - 0.027)\frac{(1-0.15)^2}{W_k^2}$$

$$= 0.027\,(1 - 0.027)\frac{(1-0.15)^2}{W_k^2}$$

In the absence of the favourite-longshot bias, i.e. if $W_k = p_k = 0.027$ one would find $\sigma_k^2 = 26.04$. Since the variance is strictly decreasing in W_k, the true variance in the presence of the favourite-longshot bias is lower, i.e. $\sigma_k^2 \leq 26.04$.

A comparison between picking a roulette number and the horse bet reveals that $E\left(R_{k,FR}\right) = -0.028 > -0.15 \geq E(R_k)$ and that $\sigma_{k,FR}^2 = 34.05 > 26.04 \geq \sigma_k^2$. Thus, the roulette bet has higher expected returns and higher variance. A risk loving agent maximizing expected utility $U(E(R), \sigma^2)$ should thus not bet on the horse, but bet his/her dollar on the roulette table. So while the favourite-longshot bias can be explained by the assumption of risk loving agents, this assumption cannot explain why risk loving agents bet on longshots at all.