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"Cognitive and emotional factors in decision-making: a comparative study between problem gamblers and non-problem gamblers"

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CHAPTER I

Gambling phenomenology

1.1. Origins

The prediction of a future event is intrinsic to all human ages. At the same time, gambling is a practice that dates back to the beginnings of humanity, constantly expanding and still spreading to our present day.

The first evidences of this activity date back to China about 5000 years ago where it was supposedly an exclusive practice of priests and seers who, throwing dice built using animal bones, had the purpose of understanding the divine will (Lavanco, 2001). Soon gambling became a social habit, a challenge not only between man and fate, but also between man and man. Romans, who believed in the existence of the Fortuna Goddess, legalized bets in fights among gladiators and “bighe or quadrighe” (the ancestors of horseracing), establishing rules and stakes to guarantee the social order[1].

During the Middle Ages, the “Baratteria” was the first location, far from places of worship or squares of the inhabited centre, where gambling was allowed. During this era, Emperor Federico II decreed that those who ran these affairs could not have administrative burdens (or be witnesses in a trial), as he suspected them to swindle people and considered them unreliable (Willmann, 1999). The Renaissance, on the other hand, recognized the right to gamble, allowing the Italian *Comuni* to introduce the so-called *gabelle*, namely the fees paid by the managers. This was followed by the spread of lotteries. Queen Elizabeth I of England instituted the first state-recognized national lottery in 1566.

The lottery has been played in Italy since 1500. Its ancestor was the “*game of the seminar*" dating back to Genoa, whose bets were linked to the biannual draw, among the 120 best personalities in the city, of the 5 who would be elected in the local Councils (*Serenissimi*

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[1] Even the Emperors Claudio, Nero and Caligula were known to be passionate gamblers (Dickerson, 1993).

Collegi). In 1638, the opening of the Venice' *Ridotto*, the first state-run playhouse, sanctioned the beginning of the gambling business era, which led to the spread of these gambling sites in other cities, as Montecarlo (in 1861) and Sanremo (in 1906). At the same time, in 1895, Charles Fey, in collaboration with Mills Novelty Company, produced *Mills Liberty Bell*, the slot machine with the *bells of freedom*. The speed and ease of use of slot machines made gambling even more enjoyable and, in 1931, the enactment of the law that legalized gambling facilitated Las Vegas Casinos in Nevada (Gherardi, 1991). Shortly after the end of Second World War, *Totocalcio* was introduced, the first betting system linked to soccer, which rapidly spread in countries where this sport was popular.

Gambling and its related socio-sanitary problems became so widespread that, in 1977, it was introduced in the International Classification of Diseases (ICD-9) for the first time. However, over the last twenty years, the various governments contributed to the unprecedented spread of new games. The first instant lottery ("*Scratch and Win*") and *Lotto*/*Superenalotto,* were created respectively in 1994 and 1997. Shortly afterwards, Betting and Bingo Halls were introduced. Even in Italy, the biggest increase in gambling took place after 2003, when the new Slot machines were legalized (Fiasco, 2014). Subsequently, Lotto's third game and new national numeral totalizer games (Win for Life) were introduced. In 2009, the Video Lottery Terminal (VLT) machines, similar to slot machines but with higher prizes and (above all) giving the possibility to play with higher stakes, proliferated. The diffusion of mobile devices (since 2008 the first online gambling websites) including poker (2011) have also been legalized (Bellio & Croce, 2014). On the one hand, this diffusion has enabled to access a variety of online services, both for free and playing with real money. On the other hand, this reduced the differences between virtual and real gambling, due also to the "live" gambling services giving gamblers, connected via webcam, experiences that are very similar to those of a real casino (Gainsbury et al., 2015).

As it can be seen from this short excursus, gambling has become a widely widespread and socially accepted pastime, although its propagation is creating considerable problems both at the individual and social levels. Gambling addiction is today one of the most serious problems that healthcare has to face.

1.2. Typology and propagation of gambling in Italy

In Italy, the Customs and Monopoly Agency[2], the new name of the authority responsible for regulating the gambling market, distinguishes the offer of public gambling in seven homogeneous categories (ADM, 2016):

- *Fixed-stake numerical games*, based on the extraction of numbers in which the potential winning amount is known a priori[3] (i.e. *Lotto* and *10eLotto*);
- *Totalizer numerical games*, also based on drawing numbers, but the potential winning amount is not known at the time of the game[4] (i.e., Win For Life, Superenalotto);
- *Sport-based games*, based on the forecast of an outcome or a combination of more events;
- *Horse-based games*, based on the ability to predict the outcome of horse racing (i.e., national horse racing);
- *Gaming machines*, where the player interacts with an electro-mechanical (*skill fishing*) or electronic (*video-poker*) device, which automatically distributes cash or other prizes in case of win;
- *Lotteries*, based on extraction of numbers, whose win amount is known at the time of the game[5]. Lotteries are divided into two categories: "Deferred Extraction" (the winning ticket is determined following a time-out draw) and "Instant extraction" (it allows to check immediately whether the combination is winning by removing the film that hides the pre-printed code, i.e., Scratch and Win);
- *Bingo*, played in equipped rooms, where it is not possible to know the winning amount in advance, as it depends on the number of played folders and winning ones.

At present, people mainly prefer playing slot machines and the latest generation of new video-lotteries (VLT), along with sports betting and Lotto sectors (mostly 10eLotto). It

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[2] ADM: Agency of the Customs and Monopoly, formerly AAMS (Autonomous Administration of the Monopolies of State).

[3] It is determined by multiplying the stake for a coefficient that is inversely proportional to the probability for the event to occur.

[4] The amount of prize money depends on the total number of games played; instead, the winning depends on the number of winning games. In "totalizator" bets, the jackpot is shared between players who have correctly predicted the betting event (or combination). Instead, in "fixed-stake" bets, bettors, in case of win, receive a sum equal to the amount of the bet multiplied by the amount determined at the time when the bet was made.

[5] Unlike fixed-numbered games, they do not require any active behavior from the player, who participates simply by purchasing the ticket.

should be noted that these games are the easiest to access, also due to their online and increasingly widespread distribution. Instead, horse betting and totalizator numeric game, such as Superenalotto, are dropping (ADM, 2016).

Although gambling in Italy has spread for so long, the lack of exhaustive studies does not allow estimating precisely the extent of the phenomenon (Serpelloni, 2013). In less than three decades, gambling revenue managed by the ADM has increased by 20 times: in 1990, tax revenue was about 5 billion Euros per year. According to recent data provided to the Chamber of Deputies (2017), the *collection* (the total bets made in one year) is about 95 billion euros (4.4% of the GDP, Gross Domestic Product) for 2016. This sum represents an 8% increase compared to the previous year, when collection was over € 88 billions. The *expense* (the collection minus gambling winnings) in 2016 is around 19 billion (1.5 billion more than the previous year). The data for 2016 represents a record testifying the return to the record levels of previous years, after the slight decline in 2013 and 2014 (comparing with 2008, since when spending on gambling has doubled).

1.3. Prevalence studies

Despite some variations in prevalence estimates, a recent meta-analysis by Calado and Griffiths (2016) reveals that studies conducted in Europe show rather homogeneous results related to the socio-demographic characteristics of gamblers. The phenomenon seems to involve largely men (Olason et al., 2015), unmarried or separated individuals (Klein et al., 2012), with a low level of education (Costes et al., 2015), belonging to minorities (Seabury & Wardle, 2014) and unemployed or having a low-income job (Meyer et al., 2015). Compared to this latter attribute, in Italy, as well as in Estonia, the relationship between income and gambling seems to be opposite to that reported in other European countries (Barbaranelli, 2013).

However, in Italy research on pathological gambling is conducted mainly on a local or regional basis, resulting in studies with an unrepresentative sample. At present, there are three prevalence studies of the gambling phenomenon: Bastiani et al. (2011), Barbaranelli et al. (2013), Colasante et al. (2013). The study of Bastiani et al. (2011), which re-elaborated data obtained from the IPSAD-Italia 2007-08 research (Italian Population Survey on Alcohol and Other Drugs), curated by the National Research Council (CNR), included 31,984 participants aged between 15 and 64. Using the Canadian Problem Gambling Index - Short form scale (CPGI, Ferris & Wynne, 2001; Italian translation of Capitanucci, 2006), the authors estimated that 42.1% of participants bet at least once in the last year: 33.8% of them were classified as "non-risk gamblers", 6.1 % as "low risk gamblers" and 2.2% as "problematic or moderate risk gamblers". The latter sub-category included 73.4% men and 26.6% women. The authors estimated a prevalence of problematic gambling in 2.3% of the young population (15-24 years) and 2.2% of the adult population (25-64 years) while, among those with slight problems, 6.9% were young and 5.8% adults.

The study of Barbaranelli et al. (2013) was conducted on a sample of 1,979 participants, aged 18 to 74, and representative of the "adult Italian population who gambled at least once for money in the last 12 months". To estimate the phenomenon spread, they used the South Oask Gambling Screen (SOGS, Leiseur & Blume, 1987; Italian version developed by Guerreschi and Gander, 2002) and the Problem Gambling Severity Index (PGSI, Ferris and Wynne, 2001; Italian translation of Capitanucci, 2006), a subset of 9 items from the CPGI. The results indicated a 1.27% problematic gambling, 1.56% risk gambling and 50.73% non-problematic gambling, while the percentage of non-gamblers was 46.44%. Moreover, problematic or risk gamblers were prevalently male (66% vs. 55%, respectively), separated (10% vs. 5%), with at least one relative with gambling-related problems (12.2% vs. 4.4%), having difficulties in managing money (28% vs. 14%) and debts (11% vs. 2%).

The study of Colasante et al. (2013), performed on a sample of 5,292 individuals, aimed to adapt the Canadian Problem Gambling Index (CPGI, Ferris &Wynne H., 2001) to the Italian context. They found that, based on this instrument, 83.2% of participants were classified as non-gamblers, 11.2% as low-risk gamblers, 4.3% as moderate risk gamblers and 1.3% as pathological gamblers.

1.4. The diagnosis of gambling disorder

A few years after the first inclusion of pathological gambling in the International Classification of Diseases (ICD-9), it also was included among the pathological disorders of the Diagnostic Statistical Manual of the American Psychiatric Association (DSM-III, 1980), in the "Impulse Control Disorders not otherwise classified" section.

In line with the scientific research of the last few years, which has placed the issues related to gambling closer to those of addiction disorders, in the fifth and last edition of DSM (APA, 2013), changes with respect to previous DSM IV can be noted. In fact, *Gambling Disorder* (GD) has changed both label and diagnostic placement, as it is included in the *Addiction* category (substance-related and addictive disorders), in a particular subcategory: *Non-Substance-Related Disorders*. Many recent studies have shown that syndrome, brain correlates and physiology, as well as GD (Gambling Disorder) treatment, are very similar to dependency-based behaviour, although they do not involve drug assumption (Dixon, 2014; Coriale, 2015; Murch & Clark, 2015). In fact, the gambler's excitement during the game would be comparable to that produced by drug intake, as well as there seems to be a correlation with an alteration of the gratification system.

Regarding the diagnostic criteria of GD, they did not undergo any significant changes, except for the deletion of the criteria concerning the enactment of antisocial acts. However, the diagnostic criteria must be evident over a maximum period of twelve months for the diagnosis to be valid, correcting the previous position according to which the diagnosis was considered throughout the life span (DSM-5, APA, 2013).

1.5. Diagnostic tools

The use of screening tools contributes to provide systematic information that can guide the individual's placement in the recreational or pathological gambling sphere. Currently there are several tools for diagnosing and evaluating the level of problematic gambling. However, the DSM criteria are the main diagnostic tools to understand crucial elements and an initial evaluation and confirming a diagnostic hypothesis of the disorder.

Among the diagnostic tools that refer to the classification of DSM (see for a review Calado and Griffiths, 2016), one of the most widely used to assess the gambling problem is the aforementioned SOGS questionnaire (Leiseur & Blume, 1987), whose results correlate with the diagnosis of DSM-III (APA, 1980). As I wrote, the Italian version has been published by Guerreschi and Gander (2002). More precisely, the SOGS is a self-assessment screening tool consisting of 20 questions, which allow to detect possible gambling problems and to know some aspects of gambler behaviour[6]. A score of 3 and 4 indicates the presence of problem gambling, whereas a score of 5 (or more) suggests the presence of pathological gambling. The SOGS is considered a reliable tool, although several studies (Lavanco, 2001; Stinchfield et al., 2010) have highlighted how it tends to overstate the number of problem gamblers ("false positives"). There is also a developed version for adolescents (SOGS-RA, Winters et al., 1993).

Other widely used tools are the above-mentioned CPGI (Ferris and Wynne, 2001) and the National Opinion Research Center Diagnostic Screen for Gambling Problems (NODS; Gerstein et al. 1999). The former tool is highly correlated with the DSM-IV criteria (r = 0.81) and with the SOGS (r = 0.80). The Italian version has been published by Colasante et al. (2013). The latter is a population-based telephone-screening tool composed by 21 item identifying gambling problems according to DSM-IV criteria. It was found to be highly correlated (r =.85; Wickwire et al., 2008) with the SOGS. At present, this tool is not available in an Italian version.

Other measures referring to the DSM are the DSM-IV Questionnaire (Ladouceur, 2000), the Fisher DSM-IV Screen (in Rönnberg et al., 1999), the Beaudoin-Cox (1999), and the Short Gambling Questionnaire (Petry, 1996).

Further diagnostic approaches relate to the classification of the disorder in obsessive-compulsive disorders (Pathological Gambling Yale-Brown Obsessive Compulsive Scale; Melli et al., 2015) and refer to an evolutionary perspective (Custer's Diagram, 1982)[7] or to a motivational approach (MAC-G, Prochaska and Di Clemente, 1988).

1.6. Gambling and personality characteristics

A large part of gambling research has investigated personality factors involved in such behaviour, focusing the attention on impulsivity and sensation seeking in particular. The first

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[6] Some examples are: preferred game and frequency with which the individual is committed; some signs of problematic gambling (chasing, lies about gambling, loss of control, etc.); individual's relationship with the family over game and money; the consequences of the game; the research for money to play.

[7] It highlights the stages of social gambling progression to pathology.

diagnostic classification of problematic gambling in the impulse control section has fostered studies to find empirical evidence for this inclusion. Impulsivity is supposed to reflect a predisposition to develop a range of addictive disorders, including non-drug-related risky behaviours, as compulsive shopping or risky sexual behaviours. Currently, impulsivity is increasingly considered a multidimensional construct where personality, cognitive (i.e. delay discounting) and behavioural (i.e. impulsive choices or actions, impaired response inhibition) aspects may play a role in gambling behaviour (Ledgerwood et al., 2009). Some studies (Finn et al., 1999; 2002; Marsh et al., 2002; Horn et al., 2003) found a significant negative relationship between response inhibition and impulsivity. Addictive behaviour of problematic gamblers may result from impaired self-regulation that, in turn, translates into the inability to inhibit a response or to shift behaviour towards another target (Goudriaan et al., 2004). Studies investigating the delay discounting (i.e. the depreciation of the value of a reward depending on the time it takes to be released) in problem/pathological gamblers and non-problem gamblers found that the former depreciated delayed reward more than non-problem gamblers[8] (Petry and Casarella, 1999; Petry, 2001; Alessi and Petry, 2003). Lejuez et al. (2002) found a positive correlation between risk-taking behaviour, measured by the balloon analogue risk task (BART), and gambling involvement. Several studies found that pathological gamblers exhibit marked levels of impulsivity (Blaszczynski et al., 1997; Vitaro et al., 1999; Nower & Blaszczynski, 2006). Ledgerwood et al. (2009) have assessed impulsivity and other personality traits in pathological gamblers (with and without substance use disorders) and in healthy controls. Different scales and tasks were used to measure specific indices of impulsivity: self-reported impulsivity (through the Barratt Impulsiveness scale, BIS), sensation seeking (Zuckermann's Sensation-seeking scale – SSS), delay discounting (Delayed Discounting of Monetary Rewards task and Single Key Impulsivity Paradigm), attention/memory (Immediate and Delayed memory task), response inhibition (Go-Stop

[8] Note that, in the presentation of the literature review, the original nomenclature used by the authors to classify participants as a function of gambling severity will be reported.

As suggested by one of the two reviewers, Prof. Luke Clark, in the three studies presented in the following chapters, the *problem gamblers* vs *non-problem gamblers* classification will be adopted to indicate, respectively, the gamblers' group and the one used as control.

Impulsivity Paradigm); risk-taking (BART), and distress tolerance (Paced Auditory Serial Addition Task). They found that pathological gamblers were more impulsive than healthy controls in specific ways. Regardless of substance use disorders, pathological gamblers discounted delayed rewards more than control participants did. Moreover, greater rate of discounting was associated with higher scores on the BIS Attention and Non-Planning subscales, where pathological gamblers showed more elevated scores than the control group. Both gamblers groups did not differ from control on sensation-seeking scores and risk-taking behaviour. Gamblers with and without substance use disorders did not differ on delay discounting and self-reported impulsivity measures as well as on sensations seeking scores.

However, the relationship between gambling severity and the personality trait of impulsivity has not always been found. Studies investigating this clinical association showed discordant results (Ginley et al., 2104; Lorains et al., 2014; Patterson et al., 2003; De Wilde et al., 2013) that may derive from the scales used. A recent study conducted by Leppink et al. (2016) examined, in 154 pathological gamblers, the clinical association between three different measures of personality (Eysenck Impulsiveness questionnaire: EIQ; Barratt Impulsiveness scale: BIS; Stop-Signal test: SST) with gambling disorder diagnosis. They found that BIS showed the most direct association with gambling clinical severity. Differently from EIQ and SST, all three domains of BIS were associated with clinical diseases. In particular, high motor and attentional impulsivity subscales were associated with gambling severity whereas high non-planning impulsivity was associated with depressive symptomatology.

Sensation seeking, characterized by a need for novel, varied and complex experiences, appears to be strictly linked to the characteristics of gambling (i.e., expectations on outcomes, risk taking). Nevertheless, the studies investigating its relationship with gambling status showed discordant results. On one hand, some studies (Kuley and Jacobs, 1988; Powell et al. 1999; Gupta et al. 2006) found higher sensation-seeking scores in problem gamblers than in social gamblers. On the other hand, in other studies pathological gamblers exhibited lower sensation-seeking scores than non-gamblers (Blaszczynski et al. 1986; Carrasco et al. 1994; Blanco et al. 1996). In addition, other studies did not reveal significant differences between the two groups (Dickerson et al. 1990; Blaszczynski et al. 1990; Coventry and Brown 1993; Bonnaire et al. 2004; Parke et al. 2004). Some authors posit that sensation seeking is a component of the impulsivity construct rather than a separate personality trait. Gullo et al. (2014) argued that impulsivity is composed by two interconnected processes (approach vs. inhibition), including personality, cognitive and behavioural levels. Sensation seeking would be comprised, together with reward sensitivity, in the personality level of the approach process whereas delay discounting and impulsive choices would be included in the cognitive and behavioural levels. Recently, Hodgins and Holub (2015) examined the structure of impulsivity construct in relation to gambling behaviour. They administered to 104 problematic gamblers both behavioural and self-report measures of impulsivity. The results found that the two emerging factors, trait impulsivity and sensation seeking, respectively correlated with problem gambling severity and involvement.

1.7. Cognitive distortions and gambling

Gambling games are mostly random (i.e., lotteries, roulette, slot-machines) or involve a little degree of skill (i.e., sports betting, blackjack). Nevertheless, research revealed that when dealing with chance human beings may recur to an erroneous processing of randomness, as showed by cognitive distortions. The cognitive approach to the gambling study highlighted that cognitive distortions have a key role in the development and maintenance of problem gambling behaviour. Using mainly psychometric measures of cognitive distortions concerning the gambling field (i.e.: GRCS: Gambling-related Cognitions Scale; GBQ: Gambling Beliefs Questionnaire), the studies adopting a cognitive approach found that people with gambling disorder reported higher levels of distorted cognitions than social gamblers (Joukhador et al., 2003; Myrseth et al., 2010) or non-gamblers (Miller and Currie, 2008; Emond and Marmurek, 2010). One of the crucial aspects of gamblers' cognitive characteristics seems to be the tendency to overestimate the likelihood of winning due to the variety of cognitive distortions (Ladouceur and Walker, 1996; Clark et al., 2010; Michalczuk et al., 2011), most of them deriving from representativeness and availability heuristics (Kahneman & Tversky, 1974). The most studied cognitive distortion related to the representativeness heuristic (the belief that an event is likely to belong to a class as it appears to be representative of that class) is the *gambler's fallacy*. Such distortion would occur when people believe that even a short run of random events correspond to their randomness conception and would lead to believe that a particular outcome is due. Another cognitive distortion related to the representativeness heuristic is the *trends in number picking* (i.e., believing that random events are instead governed by specific “laws”, according to which future outcomes are predictable): several studies have found that gamblers prefer number strings not containing close digits (Haigh, 1997) or avoid picking duplicate numbers (Holtgraves and Skeel, 1992; Rogers and Webley, 2001).

The cognitive distortions related to the availability heuristic (i.e., believing that an event is more likely when it is easily available in memory) are the *availability of others' wins*, the *inherent memory bias*, and *illusory correlations*. Griffiths (1994) found that hearing and seeing the effect of the wins of close slot machines lead gamblers to increase their subjective winning probabilities. Erroneous perceptions of a relationship between unrelated events (i.e. believing that personal luck influences gambling outcomes), as well as other superstitious beliefs, are found in gamblers (Petry, 2004).

The *illusion of control* (i.e. the belief of being capable to influence outcomes that are instead out of one's control) has been considered as another key cognitive distortion affecting gambling behaviour. This distortion, often associated with *overconfidence* (i.e., high degrees of confidence in oneself, not supported by real abilities or possibilities), would lead gamblers to assign greater value to their own choices rather than to those of other people or to randomness, even if the success possibilities are not influenced by the opportunity to choose.

Most forms of gambling deliver near misses, that is, an unsuccessful outcome close to the win (i.e., a lotter ticket differing only slightly from the winning number, or a slot machine showing two cherries with the third cherry falling close to the pay line). Several studies showed that near-miss events are perceived as more aversive than complete-miss events (Chase & Clark, 2010; Clark et al., 2013; Sharman et al., 2015), that they increase the wish to continue the game especially when the possibility of personal control is present (Clark et al., 2009).

Among the possible cognitive distortions, the illusion of control and the gambler's fallacy have received particular attention and have been strongly associated with gambling disorder (Goodie and Fortune, 2013; Clark, 2014). They will be widely discussed in the second and third chapter, respectively.

1.8. Emotion and gambling

The relationship between emotion and gambling behaviour is a topic of growing importance in gambling research. It will be discussed extensively in the fourth chapter, where a study aimed to investigate the influence of positive and negative discrete emotions, induced through the autobiographical recall technique, on problem gamblers and non-problem gamblers' decision-making will be reported.

Overview of the studies

In the next three chapters three studies will be reported, in which the effects of two cognitive distortions (the illusion of control and the gambler's fallacy) and some induced emotions (anger, fear, sadness, joy) on problem and non-problem gamblers' decision-making have been respectively investigated.

Specifically, in chapter II, a study aimed to investigate the putative existence of the illusion of control in problem and non-problem gamblers will be presented. Such study examined whether previous outcomes associated with personal and random choices in a gambling task influenced the winning probability estimates (linked to personal or random choice of the next event to bet on), the selection of the choice-agent, and the bet amount.

Chapter III is focused on a study investigating the occurrence of the gambler's fallacy (or the hot hand fallacy) and its relationship with probability estimates of the next outcome and the bet amount. Such study examined whether a series of identical outcomes induced one of the two fallacies and whether the induced fallacy was linked to an increase in probability estimates of the target event and in bet size.

Finally, chapter IV will be centered on a study on the effect of positive and negative emotional states on decision-making. Such study examined whether the activation of incidental discrete positive/negative emotions was accompanied by a change of physiological parameters, whether the induced emotional states would affect the participants' bet choice and whether such choices were influenced by the physiological arousal.

The three studies also investigated whether such effects were present to a different extent in problem and non-problem gamblers.

The two samples were recruited among residents in the Campania region. Problem gamblers were recruited among users requiring assistance in different Gambling Addictions Services[9]. The managers of the structures were demanded to select only problem gamblers who did not have comorbidity with other psychopathologies (e.g. drug addiction) and had not

[9] These services are placed in the frame of the Drug and addiction services, but they are specifically devoted to gambling addiction.

yet undergone psychological treatment. Non-problem gamblers were recruited among relatives and friends of problem gamblers or by means of posters placed in the same addiction services or in local pharmacies, gyms, and medical and physiotherapy practices. The two groups of participants were paired by age and educational level. All participants were male since in Italy, and more specifically in the region where the studies have been conducted, problematic gambling affects more males than females.

As it will described in the first study, the main gambling activities performed by problem-gamblers' group were Sports betting (more than once a week: 53%), Slot machines and VLT (26%), Cards games (11%) and Lotteries (10%). The gambling forms that were played by the problem gamblers group were assessed through the item 1 of the SOGS, as the Gambling Addictions Services could not provide such information in order to respect user privacy.

Each of the three studies consisted of a quasi-experiment where one of the independent variables was always the participants' *gambling status*, which was not manipulated.

In the first two studies, presented in a counterbalanced order, participants were invited to take part in a fictitious American roulette game (modified *ad hoc*, by excluding the two green slots associated with 0 and 00), consisting of an equal number of red (50%) and black (50%) slots where the white ball could land. In both experiments, participants were presented with twelve balls throws. At the thirteenth and final round, they were asked to estimate the percentage probability of both winning possibilities (in the illusion of control study) or of both outcomes (in the gambler's fallacy study). Then, they were asked to make a choice (personal or random, in the illusion of control study, or between one of the outcomes, in the gambler's fallacy study) and, finally, to indicate how much they would bet on the choice made.

The study investigating the effect of emotions on decision-making was presented in the end of the experimental session in order to avoid interferences with the first two studies, because the experimental procedure required the setup of electrodes for the measurement of physiological parameters. In this study, after the emotional induction by the autobiographical recall technique, participants took part in four decision-making tasks, representing four game situations that differed from each other as a function of the ownership of hypothetical money used to play and of winning probabilities.

At the end of the three studies, participants completed, in a counterbalanced order, the Barratt Impulsiveness Scale (BIS-11) and the Brief Sensation Seeking Scale (BSSS). The scale scores were considered as covariates in each of the three studies in order to investigate the role of personality factors (impulsivity and sensation seeking) in gambling behavior, as, according to the literature previously discussed, this relationship remains unclear.

Finally, participants completed the SOGS, which was used as further tool to distinguish between problem and non-problem gamblers, as it will be specified in the first study.

In none of the three studies monetary incentives were contemplated for two main reasons. As several authors (e.g. Kühberger, 2001; Read, 2005) argue, the presence of economic incentives is not necessary to evaluate how people behave in hypothetical contexts, as they already have an "intrinsic" motivation to do their best so the (extrinsic) monetary incentive does not necessarily increase their level of motivation. Moreover, providing real winnings would have created ethical problems with seeking-treatment participants and neither the heads of Gambling addiction services nor the department ethics committee would have consented this procedure.

The three experiments were carried out in apposite rooms provided by the Gambling Addiction Services of Campania, in a single experimental session lasting about 1h. Due to the enormous difficulty in recruiting problem gamblers, participants were the same for all three studies. Before each experimental session, they signed the informed consent.

At the end of the third study, participants were thanked and carefully debriefed. During the debriefing, participants were clarified about the research hypotheses and it was ensured that they had not suspected the studies purposes during the experimental sessions.

The three studies were approved by the Ethics Committee of the Department of Psychology of the University of Campania "Luigi Vanvitelli", to which my tutor belongs.

Note that the characteristics of participants, recruiting methods and aspects of experimental procedure, that were common in the three studies, will be described only in the first presented study.

CHAPTER II

The illusion of control in problem gamblers and in non-problem gamblers

The first description of the concept of illusion of control was provided by Langer (1975), who defined it as the erroneous attribution of accidental positive outcomes to personal abilities rather than to chance. This definition is based on the hypothesis that people can confuse situations depending on chance with contexts where personal skills are required. According to Langer, such confusion would be generated by the presence in causal situations of features that can be interpreted as “skill cues”: familiarity with the task, opportunity of choosing, active involvement, competition, predictability of an event. In a series of experiments, Langer (1975) showed that, in purely random contexts, people tended to act as if they were able to control outcomes unrelated to their actions. In fact, participants who were given the opportunity to personally choose a lottery ticket later refused to trade it with others having more odds to win. Similarly, people who had the opportunity to select personally tickets subsequently requested a higher price to resell them than those whose tickets were randomly assigned ($ 8.67 vs. $ 1.96). Based on the people’s confusion between chance and skills hypothesized by Langer, these results express people’s tendency to overestimate the control that personal actions have on a situation and its outcome. Such tendency is implicitly associated with an increase in perceived success probabilities[10].

Subsequently, the phenomenon described by Langer was interpreted using two opposing explanatory hypotheses, i.e. *control heuristic* (Thompson et al., 1998) and *erroneous perception of control* (Gino et al., 2011). Moreover, it has also been linked to *preference for agency* (Tversky and Wakker 1995, Chew and Sagi, 2006; 2008; Abdellaoui et al., 2011). These hypotheses will be discussed in the next paragraph.

[10] Langer defined the illusion of control as “an expectancy of a personal success probability inappropriately higher than the objective probability would warrant” (p.313, 1975).

2.1. Theoretical interpretations and empirical evidence

According to Langer & Roth (1975), in tasks involving personal abilities, a steady sequence of wins or losses is predictable, whereas in casual tasks outcomes are much more variable. Therefore, winnings and losses can be a clue to determine the controllability of a task. For this reason, in a casual task, a consistent sequence of winnings or losses can increase perceptions of controllability.

In order to test such hypothesis, several authors (Langer & Roth, 1975; Ladouceur et al., 1984; Burger, 1986; Coventry & Norman, 1998; Matute, 1995; Ejova *et al.*, 2013) investigated the relationship between the perception of control and positive/negative outcomes (perceived failures or successes) in a situation. In such experiments, the presentation scheme of the wins varied in tasks where it was required to predict the outcome of a random sequence. Although the same number of wins was presented to all participants, a run of wins was presented in a condition at the beginning of the sequence (descending progression) and in another one at the end (ascending progression). In a third condition, instead, the wins were presented in random sequence. Results emerging from these studies were not consistent. Some studies (Langer & Roth, 1975; Ladouceur et al., 1984; Burger, 1986; Coventry & Norman, 1998) found control to be greatest in the “descending” condition, where people receiving a descending sequence of wins believed they were more likely to win in the future. On the contrary, other studies (Matute, 1995; Ejova *et al.*, 2013) found that inferred control was more present in the “ascending” condition, where people receiving an ascending sequence showed an increase in perception of task learning.

The studies above mentioned have varied the presentation order of wins into a seemingly casual task. Other authors (Alloy & Abramson, 1979; Tennen & Sharp, 1983; Thompson et al., 2004; 2007) have instead operationalized the positive and negative outcomes of an action through the frequency of the reinforcements, that is, the number of times the target event occurs after one’s action. Studies adopting the "contingency judgments" paradigm[11] (Alloy & Abramson, 1979) showed that, when a specific action is followed by the desired outcome, people tend to experience the illusion of control, even if actually their own behaviour has no causal link with the occurrence of the event target. Using this procedure, Thompson et al. (2004; 2007) have shown that, under non-contingent conditions, although an outcome is random and does not depend on the participants' behaviour, those who more frequently see the outcome as a result of their own action (high reinforcement) provide higher control estimates than those whose outcome occurs with a lower frequency (low reinforcement).

According to Thompson et al. (1998), people, in evaluating their own personal control, use a "*control heuristic*" based on the estimate of the *connection* (between an action and its outcome) and the *intention* (to achieve the expected outcome). In other words, when people perceive a connection between their own behaviour and a specific result, and an intentionality, based both on the desirability of the outcome and the motivation to engage in a consistent effort to obtain it, they can increase their own perception of causality over the outcome appearance, thus increasing personal control estimates.

In one of their studies (Thompson et al., 2004), participants were assigned to four experimental conditions based on the manipulation of the *reinforcement* (high/low) and *motivation* (presence/absence of a monetary incentive). Their task was to understand their degree of control over the appearance of the target stimulus by pressing or not a button. In line with their hypothesis, the results showed that the effect of the reinforcement on personal control judgments was "mediated" by the perceptions of *connection* between their actions and its outcome. In addition, the motivation to obtain the outcome led participants to overestimate their control[12].

According to these authors, the illusion of control may also occur in situations of actual control, that is, in contingency situations. In a subsequent study (Thompson et al.,

[11] In the classical version of this paradigm, in each trial participants decided whether to take an action (press a button) to obtain a target event (the appearance of a light) and, in the end, they were asked to indicate their own degree of control over the event appearance.

[12] In the high-reinforcement condition, participants motivated to obtain the outcome overestimated their control.

2007), where the actual control (none, medium, high) and reinforcement (high, low) were manipulated, people overestimated their control in the condition with high control and high reinforcement, but not in the condition with medium control and high reinforcement. Furthermore, several participants underestimated their control. Actually, not all authors agree with the universality of the illusion of control. In this regard, Gino et al. (2011) hypothesized that people have an imperfect knowledge of the actual control exerted on events, so they tend to overestimate control when it is low (or non-existent) while tend to underestimate it when it is high.

In their study, participants were presented with a white screen with a random sequence of black letters. With a 5 seconds frequency, the screen colour turned black and the letters became purple. The participants' task was to find two consecutive equal letters. The control[13] was manipulated by varying the probability that, by pressing a button, participants could hold the white screen to read letters better (experiment 1 and 2). At the end of the trails, the perceived control measures were recorded through both the control estimates (as much control as participants believed they had when trying to stop the page-colour changing), and the effectiveness (of their action to cause the desired outcome).

In line with their hypotheses, results of experiment 1 showed that participants overestimated their control in low control conditions whereas they underestimated it in high control ones even if, as regard the effectiveness, participants believed they had greater control in the high-control conditions than low and no control ones. Such tendency was confirmed in experiment 2. In experiment 3, using the "stimulus appearance" paradigm, the degree of control[14] and motivation[15] was manipulated. Participants' task was to understand their own degree of control over the appearance of the target stimulus on a screen. Results showed that, in estimating the perceived control, participants in high-control conditions provided estimates higher than those in low-control ones while, in estimating contingencies between their own actions and outcomes, participants in both high and low control conditions showed control

[13] Four control levels: high: 85%, medium: 50%, low: 15%, nil: 0%.
[14] Low or high, depending on the percentage with which two possible actions (pressing or not a button) would produce the appearance of a stimulus.
[15] Motivation was manipulated through the presence/absence of reward (i.e. some money).

estimates below the actual effectiveness of their actions. In addition, in line with the control heuristic's hypothesis, participants in highly motivated condition (possibility of receiving a reward) provided higher control estimates than those in lowly motivated condition (absence of reward).

Other authors (Tversky and Wakker 1995, Chew and Sagi, 2006; 2008; Abdellaoui et al., 2011) separate the illusion of control, which implies overestimating the probability of personal success, from the preference for agency, where the probability is estimated correctly. According to these authors, people's proneness to control would be better explained by a *preference for agency*. Chew & Sagi (2006, 2008) highlighted that this tendency is not guided by an overestimation of personal success probabilities, which are exactly estimated, but rather by a *source preference*. For example, when an individual has to choose between a lottery ticket he/she personally selected and one chosen by a third party, he/she may prefer to choose autonomously, even though he/she is aware that in both cases winning odds are the same.

Li (2011) posits that people may have different preferences towards control (preference for control, preference for no control, and preference for randomization). He found that preference toward control was not due to a bias in probability belief but rather to the source preference. In his study, which consisted of two experiments, participants were presented with an urn with 10 balls and winning possibilities depending on the extraction of the ball whose number corresponded to one of the three held by participants. Participants' task was to choose whether they wanted to select the numbers personally or let the experimenter do it. In addition, they had to indicate the related winning probabilities and to make a bet on both cases.

Results showed that people preferred to choose personally the numbers on which to bet, and they were also willing to pay a fee in order to do it. Nevertheless, regardless of who chose the numbers, most participants were aware that the odds of winning were the same. Only less than 5% of participants evaluated winning probabilities to be higher in the case of self-performed selection. Among these, 90% preferred to personally select the numbers. Thus, the author inferred that people with erroneous probability estimates are more likely to exhibit the illusion of control.

2.2. The illusion of control in problem gamblers

In some gambling contexts, such as roulette, dice or slot machines, where the outcomes are completely random, any perception of control can be certainly considered illusory. One of the hypotheses advanced to explain the development and maintenance of gambling behaviour is that the illusion of control is higher in problem gamblers than in non-problem gamblers. Thus, some researchers have focused their research on the relationship between gambling and the illusion of control. In order to investigate the variables described by Langer, a field study conducted by Davis et al. (2000) examined the role of personal *involvement* in playing craps in a casino. Bets on the first throw and on total throws were compared with those of another yoked patron[16]. The results showed that participants bet more when they threw the dice themselves than the throws were made by another player, both on the first throw and all through the game. Similar results were obtained from a laboratory study conducted by Ladouceur & Sevigny (2005), which investigated the effect of the possibility to perform an instrumental action on beliefs and persistence at Video Lottery Terminal (VLT) game. In the first experiment, participants (49 occasional gamblers) took part in a VLT game and, at the end, were administered a questionnaire aimed to investigate the effects of the possibility of stopping device on the illusion of control and related erroneous beliefs[17]. The experimental session included two phases, which differed only because in the second one participants were given the possibility to use a button to stop (*control*) the machine. Results showed that, after the first phase, no participant developed any of the four beliefs; on the contrary, in the second phase these occurred after they used the button. Additionally, the probability of developing the illusion of control, represented by the increase in winning probabilities, was much more present (5 times greater) in participants who believed skills played a role in the game than in those who did not develop this belief.

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[16] At the craps table, all players play against the dealer, so they can also bet on others' throws.

[17] Erroneous beliefs investigated: Believing that they themselves could influence the outcome (symbols on screen) using the stopping button; believing that there is a method to control the game outcomes; believing that personal skills had a role on game outcomes; developing false strategies to increase the chances of winning after using the stopping device (the latter measuring the illusion of control).

In the second experiment, the effect of the button stopping the machine on game persistence (measured by the number of turns played) was investigated. An experimental group played at VLT using the button to stop the machine while a control group played without it. At the end of the game, both groups were administered the same questionnaire as in the first experiment. Results showed that participants using the button played twice as much as the control group. In addition, similarly to the first experiment, the control group did not develop any of the four beliefs, while experimental group developed the four illusions to an extent almost identical to the first study.

More recently, pathological gamblers were found to make greater overestimations of control, compared to a healthy group, on a contingency judgment task (Orgaz, Estévez, & Matute, 2013). Participants were presented with a scenario where they were asked to imagine being a doctor testing a medicine (Batatrim) to cure a disease (Lindsay syndrome). They had to decide whether to administer the drug, which could have side effects[18], to a fictitious patient for a total of 100 trials, and then received a feedback on successful (or unsuccessful) healing: regardless of participants' choice, positive outcome of treatment was reported in 80% of cases. At the end of the trials, participants were asked to indicate (on a scale from 0 to 100) the drug efficacy: since the outcome occurred regardless of the participant's choice, the higher than zero estimates were index of illusion of control. Results showed that both groups overestimated the contingency between their own actions and the outcomes, with such overestimation being higher in gamblers group compared to the control one. Additionally, there was a positive correlation between the likelihood of drug administration and control judgment: as the number of administrations increased, there was an increase in the illusion of control. It should be noted that, since the likelihood of drug administration was not different between pathological gamblers and control group, the illusion of control of pathological gamblers was not associated with a greater number of drug administration.

[18] This information was given to prevent administrations taking place every time.

2.3. Illusion of control, probability estimates, and betting

Although the processes underlying the illusion of control are subject to different explicative models, there seems to be a general agreement on the hypothesis that this belief implies an overestimation of the occurrence probability of the chosen event following a personal choice. However, most studies have only *implicitly* investigated the probability estimates of the occurrence of an event caused by a personal choice.

Most studies involve an experimental procedure that require participants to select the target event personally or let another agent choose for them and/or to indicate (i) if they are willing to pay a fee to personally choose the target event (Charness & Gneezy, 2010; Grou & Tabak, 2008; Li, 2011), (ii) their level of confidence in such choice (Kool et al., 2013) or (iii) both (Tobias-Webb et al., 2017).

For example, in the Charness & Gneezy's study (2010) participants had to choose three numbers on the face of a die, of which only one extracted number would cause a win. Based on the four experimental conditions, participants had to (i) choose the numbers themselves, (ii) let the experimenter do it, (iii-iv), decide who (between themselves or the experimenter) would choose (freely or under fee payment). The results showed that personal choice dropped significantly when choosing between the two options implied a payment. Previously, Grou & Tabak (2008) using a similar procedure had obtained analogous results. In fact, they found that most participants chose to personally roll the die when it was free while only low percentages paid the fee for do it. Differently, in Kool et al. (2013), participants indicated their level of confidence in personal and imposed choices that would result in a win outcome. Their task was to select one of three spinners (wheels of fortune) containing a win sector. The three spinners had equal probabilities to result in a win. The size of the win sector varied between trials, while remaining the same within the three spinners. Depending on approval/vetoed condition, participants' choices were next approved or vetoed and replaced by another one. The results showed that participants assigned higher confidence ratings to gambles that they chose than for the equivalent ones that were imposed. The results showed that participants assigned higher confidence ratings to gambles that they had chosen rather than to gambles that had been imposed. The confidence ratings were also sensitive to win sector size, as they increased as the amount increased.

More recently, in Tobias-Webb et al. (2017), participants took part to the card-guessing task, in which they had to find the winning card rotating a device. The control was manipulated in three conditions, where participants could exercise the control, freely or paying a fee, or not (baseline). Subsequently, they had to indicate the level of confidence (on a Likert scale from 0 to 100) to find the winning card. The authors found that the level of confidence was higher when participants exerted control than in the baseline condition. Moreover, participants were more likely to exercise control when their confidence was high, and this effect was accentuated in the pay condition relative to the free condition.

As regards the procedure to investigate the occurrence probability of an event related to a self-performed choice, most studies used an indirect measure of probability estimates. Also in Li's (2011) study, participants were asked to evaluate and choose whether they believed to have a higher probability in case of self-performed or experimenter’s choice or if the probabilities were the same in both cases. The procedure used in Ladouecer & Sevigny's (2005) study, instead, required participants to indicate whether and which strategies increased their winnings probabilities. Other studies have estimated subjective perceptions of control over the appearance of the desired event through different Likert scales, which evaluated winning expectations (Wohl & Enzle, 2002) or the effectiveness of their own actions (Vadillo et al., 2013; Matute & Blanco, 2014).

Using a procedure analogous to Langer’s (1975), Wohl & Enze’s study (2002) showed participants who were given the opportunity to personally choose a lottery ticket reported winning expectations (measured on a 1 to 7 point Likert scale) higher than those who had their ticket randomly assigned by a computer. In addition, participants who could select the tickets perceived themselves as more fortunate and believed that luck was a personal quality more than the other group did. Moreover, winning expectations correlated positively with fortune perceptions, since they paired with the growth of fortune perception as a personal quality. Vadillo et al. (2013) have instead shown that providing accurate information on alternative factors able to affect causal relationships can reduce the control illusion.

Participants were presented with an aversive stimulus (a sound) and their task was to eliminate it. In the experimental group, the disappearance of the stimulus was preceded by the presence of a signal (asterisk). Then they were asked to indicate (on two Likert scales from 0 to 100) if the disappearance of the stimulus was influenced by the signal and their behaviour. As expected, the results showed that the participants to whom the signal was presented estimated the disappearance of the stimulus as more influenced by the signal with respect to the group control[19]. Subsequently, Matute & Blanco (2014) showed that the illusion of control increased when a recurring undesirable outcome was attributed to alternative causes and this was associated with the use of a strategy where an action caused the outcome 50% of the time[20]. Using a procedure similar to the one above described for the study of Vadillo et al. (2013), participants were told that an undesired stimulus (a blue and white flash) would appear on the screen and that their task was to eliminate it (making the screen black) by pressing a button. Unlike the control group, participants in the experimental group received additional information: 1) the button could not work in some cases 2) they were advised to use the strategy where their action caused the desired outcome 50% of the time. The undesired stimulus sequence was manipulated so that, in both group, 75 % of the trials failed to keep the screen black. As expected, participants in the experimental group performed their action avoiding the undesired stimulus less frequently than the ones in control group. Therefore, they attributed the recurring undesired stimulus less to their actions and, more importantly, they could attribute it to an alternative cause. On the contrary, participants in the control group estimated their control to be less effective, as they could not attribute their rare successes to their frequent actions[21].

Only Dixon's (2000) study explicitly investigated the probability estimates of a target event following a personal choice. In this study, conducted in a laboratory setting with a

[19] However, both groups showed the illusion of control, as in both groups the effectiveness estimates of their responses were higher than zero.
[20] This strategy aims to find out if one’s behaviour is effective.
[21] However, even in this experiment, both groups showed the illusion of control as in both groups control judgments were higher than zero.

sample of five women playing roulette, the (accuracy vs. inaccuracy) game-related rules[22] and (personal vs. made by experimenter**)** choice of the numbers on which to bet varied.

After a baseline game session, in the next two ones participants were first presented with three inaccurate rules related to roulette and then were presented with three accurate ones. At the end of each game session, participants were asked to estimate the winning probabilities, both when the choice was made by oneself and when it was made by the experimenter. Results showed that, before presenting any rule, participants tended to overestimate winning probabilities in case of a personal choice and to underestimate them when the experimenter selected the numbers. A similar more substantial pattern was observed after the presentation of inaccurate rules. Differently, after the presentation of the accurate rules, participants provided correct probability estimates in both selection modes. However, in a follow-up session they returned to overestimate winning odds in case of personal selection. A similar effect was also found with bets since, prior to the presentation of the rules, four participants bet more when they personally chose numbers compared to when the experimenter selected them. Moreover, also in this case the difference tended to decrease by introducing accurate rules and to return in the follow-up session.

Further studies have also investigated the relationship between the (personal vs. by another agent) choice of an event and the bet on the outcome of such event. In such experiments, after selecting an event by one of these two options, participants had to decide how much to bet on the occurrence of target event. Such studies found discordant results. On the one hand, studies conducted on both heathy individuals (Koehler et al., 1994; Chau & Phillips, 1995; Li, 2011) and gamblers (Davis et al., 2000) found that the highest bets were positively correlated with the illusion of control. On the other hand, the abovementioned studies of Charness & Gneezy (2010) and Grou & Tabak (2008) found that, although preferences for personal selection was higher when it was free compared to when it implied a cost, the bets made in the two conditions did not differ. Moreover, bets in case of personal

[22] Three inaccurate vs. accurate roulette game rules:
In order to win, personally picking up the numbers is necessary/indifferent;
in order to obtain a big win, big bets are not/necessary;
im/possibility to voluntarily draw the numbers that make a player lose.

selection did not even differ from the ones made when it was the experimenter who selected the numbers.

3.4 Theoretical and methodological differences in the research on the illusion of control

As it could be seen from the literature review, there are both theoretical and methodological differences in the research on the illusion of control. From a theoretical point of view, some authors (Tversky and Wakker 1995, Chew and Sagi, 2006; 2008; Abdellaoui et al., 2011) have distinguished the illusion of control (involving erroneous probability estimates) from the preference for agency (in which probabilities were correctly estimated). Other scholars have disputed the Langer's interpretation of the phenomenon, in favour of the control heuristic (Thompson, 1998; 2004; 2007), according to which people overestimate their control on events only when both intentionality and connection converge toward an (expected) outcome. Furthermore, few authors have advocate the existence of an erroneous perception of control (Gino et al., 2011), or a variable preference for different sources of control (Li, 2011).

Also from a methodological point of view, there are consistent differences among the studies. Most of them have used an experimental procedure in which participants were required to select personally the target event or let another agent choose for them. In other experimental paradigms using non/contingency task, in every trial a feedback on the performed action was delivered to participants, both pathological gamblers (Orgaz et al., 2013) and healthy individuals (Alloy and Abramson, 1979; Thompson, 2004; 2007; Vadillo et al., 2013; Matute & Blanco, 2014), who were asked to estimate their subjective perception of control over a target or desired outcome. Some scholars (Langer & Roth, 1975; Ladouceur et al., 1984; Burger, 1986; Coventry & Norman, 1998; Matute, 1995; Ejova et al., 2013) investigated the effect of previous positive/negative outcomes on the perceived control with discordant results. Only a few studies (Dixon, 2000; Li, 2011) have simultaneously examined the variables involved in the phenomenon.

Although the processes underlying the illusion of control are interpreted by different explicative models, there seems to be a general agreement on the hypothesis that the illusion of control is linked to an overestimation of the probability of occurrence of the chosen event following a personal choice. However, most studies have only implicitly investigated the probability estimates of a target event. For example, in the Langer’s classic experimental procedure (Langer, 1975; Wohl & Enze, 2002), participants were asked to indicate, by different Likert scales, their winning expectations. Ladouecer & Sevigny's (2005) study required participants to indicate whether and which strategies increased their winnings probabilities. So far, only Dixon’s (2000) study explicitly investigated the probability estimates of the occurrence of a personally chosen event. Indeed, at the end of the game session, participants were asked to estimate the winning probabilities, both whether the choice was made personally and by the experimenter.

Finally, it should be remarked that one of the explanatory hypotheses on the development and persistence of pathological gambling is that gamblers are particularly susceptible to cognitive distortions, such as the illusion of control, which would cause a tendency to overestimate the winning probabilities (Griffiths, 1994; Ladouceur & Walker, 1996; Miller & Currie, 2008; Romo et al., 2016). However, to the best of my knowledge, so far only the study of Orgaz et al. (2013) has specifically investigated whether the illusion of control phenomenon is present in a different extent in problem gamblers and non-problem gamblers comparing their performance in a gambling task.

Overview of the study

The present study aimed to investigate the putative existence of the illusion of control in problem gamblers (PG) and non-problem gamblers and its relationship with probability estimates and wager size in a gambling task. Specifically, the study examined whether previous positive/negative outcomes associated with *personal* and *random* choices influenced (i) the probability estimate of winning linked to the personal choice and the random choice of the next event on which to bet (ii) the selection of the choice-agent, (iii) the bet amount.

A specific goal of the study was to disentangle the *illusion of control* (where winning probabilities are overestimated) from the preference for *agency* (where probabilities are correctly estimated). In addition, the study aimed to investigate whether one or the other phenomenon was present to a different extent between PG and non-problem gamblers and whether personality factors, such impulsivity and sensation-seeking, affected the participants' responses.

To this end, it was created a quasi-experiment with a 4 x 2 factorial design, with two independent variables, one of which (experimental condition) was manipulated whereas the other (problem gamblers vs. non-problem gamblers) was not. The four experimental conditions were created manipulating the number of winning and losing outcomes associated with choices made personally by the participant and randomly by the computer, in a fictional American roulette game, modified ad hoc for the study, by eliminating the two green slots (see Materials and procedure section). Participants played 12 fake rounds: they could choose personally the slot color on which to bet in six rounds, whereas the computer made randomly the choice in other six rounds. In order to avoid the order effect, the possibility of choice by the participant or by the computer was presented randomly.

Actually, the outcomes of the first 12 rounds were predetermined in order to present, in each condition, a specific outcome sequence differing from the other in the number of wins and losses associated with the choices made personally by the participant and randomly by the computer. More specifically, in a condition, the personal choices mostly resulted in wins and the ones made by the computer were balanced between wins and losses (first). In other two conditions, the personal choices mostly resulted in losses whereas the ones made by the computer were balanced between wins and losses (second) or were mainly winnings (third). In a control condition, the outcomes both of the personal choices and the ones made by computer were equally distributed in wins and losses.

At the thirteenth and final round, participants were asked to estimate, in percentage, the winning probability they had if they personally chose what colour to bet on, and the winning probability if the computer chose. Then, they were asked to choose whether they wanted to let the computer make the choice of the colour on which to bet or if they wanted to choose personally and, finally, how much they would bet.

The hypotheses underpinning the study concerned three issues: (i) the illusion of control (ii) the choice of the agent, (iii) the bet amount. For each issue, three contrasting expectations were advanced.

The hypotheses about the illusion of control were the following:

1. If people were prone to the illusion of control, then they should believe that, choosing personally the colour on which to bet, they should have more possibilities to win compared to the random choice made by the computer; this should occur both in the condition where the personal choices mostly resulted in wins and in the control one.
2. Instead, if people were prone to the influence of previous outcomes, then they should believe that the probability of winning associated with the personal choice and with the computer-made choice vary depending on experimental conditions. In particular, the winning probability associated with the personal choice should be expected to be higher in the condition where the personal choices mostly resulted in wins. Analogously, the winning probability associated with the choice made by the computer should be expected to be higher in the two conditions where the personal choices mostly resulted in losses, while the outcomes of the choices made by the computer were either balanced between wins and losses or were mainly wins.
3. If people were not prone to any of the two phenomena then the two probability estimates should not vary.

The hypotheses about the choice of the agent were the following:

1. If people desired to be agents of their own fate, then they should always prefer personal choices regardless of the winning probability attributed to the personal choice or the one made by the computer. Therefore, if participants made correct probability estimates but preferred to choose themselves, they would show a preference for agency but not the illusion of control.

2. If participants were prone to the influence of the previous outcomes, they should prefer to choose themselves in the condition in which personal choices are predominantly winning and let the computer choose in the conditions where the computer choices are predominantly winning. Note that the influence of previous outcomes on preference for agency could be independent from that on probability estimates.
3. If people were insensitive to both phenomena, they should not reveal any preference for the decision-maker: so the proportion of personal choices should be similar to the one of computer choices.

Similar contrasting hypotheses were made for bet amount:

1. Betting more in case of overestimation of winning probabilities linked to personal choices would be an additional index of illusion of control. Also betting more after having opted for personal choice (without overestimating personal winning probabilities) should be considered an indicator of the illusion of control, since such behavior would suggest that positive outcomes were expected by personal rather than random choices.
2. On the contrary, if the bet amount varied in function of the experimental conditions (i.e. if it increased following the "winning" conditions and decreased following the "losing" ones), people would be prone to the influence of previous outcomes.
3. If people were insensitive to both phenomena, bet amount would not vary across the experimental conditions.

In conformity with several evidences in the literature (e.g. Lim et al. 2015; Michalczuk et al. 2011; Myrseth et al. 2010; Nower et al., 2004; Petry, 2001), it is expected that problem gamblers are more prone than non-problem gamblers to the illusion of control and to impulsivity and sensation-seeking. Moreover, it is expected that higher scores on sensation-seeking and/or impulsivity scales are positively associated with the illusion of control and the bet amount.

It must be specified that the decision to request the *probabilities* estimates before choosing the agent selecting the slot colour aimed to avoid both that the participants could misinterpreted the questions on probabilities as questions about their *confidence* in the possibility of winning and/or that they could indicated how *lucky* they felt *after* their choice.

Furthermore, the purpose of asking two questions about the probability estimate was to understand both whether the participants overestimated one of the two outcomes (or both) and if they perceived them as complementary or independent from each other. The modification of the roulette, by eliminating the two green slots, aimed to maintain the probability level of each event constant to 50% and to allow participants to choose between two equiprobable events.

Experiment

The next paragraphs will describe the characteristics of participants and recruitment methods, which are analogous for the three experiments.

Participants

Three hundred twenty male[23] unpaid volunteers (N=40 for each condition) of Italian nationality, aged between 18 and 68 years (mean = 34, SD = 10.451), took part in the three studies. All participants signed the informed consent form, in which anonymity was guaranteed. The only information required was age and educational level. They were also told that they could stop the experiment at any time.

Participants were recruited among the residents of the provinces of Naples, Caserta and Salerno.

Participants were recruited among the residents of the provinces of Naples, Caserta and Salerno. Pathological gamblers were recruited in different Gambling addiction Services, among those requiring assistance. As I already wrote, they did not have comorbidity with other psychopathologies. Moreover, they had not yet undergone psychological treatment. Indeed, since the three studies aimed to investigate putative differences between pathological

[23] The participants were all male because the incidence of women among problem gamblers was reduced and it would not have been possible to make homogeneous groups by sex.

gamblers and healthy individuals (henceforth problem gamblers/non-problem gamblers), we ensured to avoid that any positive effect of psychological treatment would reduce the differences between the two groups of participants. Non-problem gamblers were recruited among the relatives and friends of problem gamblers or by means of posters placed in the same Gambling addiction Services or in local pharmacies, gyms, medical and physiotherapy practices. The two groups were paired according to age and educational level.

Note that to use an additional discriminant criterion between problem gamblers and non-problem gamblers, at the end of the three experiments the South Oaks Gambling Screen (SOGS, Lesieur & Blume, 1987) was administered. In this way, we aimed to eliminate from the non-problem gamblers group the participants having high scores on the SOGS and from the problem gamblers group those having low scores on the SOGS. Actually, no change in the two groups was needed: the few problem gamblers (about 15) who scored borderline on the SOGS (i.e. 4) were left in the problem gamblers group. The participants of the non-problem gamblers group scored from 0 to 2 on the SOGS.

The choice to use the SOGS was based on the observation that it is the mainly used screening tool in clinical and research in Italy. It was used as a further instrument of discrimination between the two groups and also to obtain information on the gambling forms played/preferred by the problem gamblers. All participants (problem gamblers and non-problem gamblers) performed the tasks in appropriate rooms provided by the Gambling addiction Services. Each participant performed the tasks individually. No money incentive was offered.

The studies were approved by the Ethics Committee of the Department of Psychology of the University of Campania “Luigi Vanvitelli”, to which my tutor belongs.

Design

This study was a quasi-experiment with a 4 x 2 factorial design. Participants were divided into eight groups on the basis of two between-subjects variables: *experimental condition (with four levels, described later),* which was manipulated, and *gambling status (with 2 levels: problem gamblers vs. non-problem gamblers)*, which was not manipulated. The four dependent variables will be described below.

In this study, as well as in the other two studies subsequently described, 2 covariates were considered: the *impulsivity* level, measured through an Italian version of the Barratt Impulsiveness Scale 11 (BIS-11, Patton et al. 1995, Italian version validated by Fossati et al. 2001) and the *sensation-seeking* level, measured through the Italian version of the Brief Sensation Seeking Scale (BSSS, Hoyle et al., 2002, Italian version validated by Primi et al., 2011). Note that these last two measures were revealed once, at the end of the three experiments.

Materials and procedure

In each of the experimental conditions, participants were invited to play in a fictional American roulette game (modified ad hoc, by excluding the two green slots associated with the 0 and 00 numbers) consisting of an equal number of red (50%) and black (50%) slots where the white ball could land.

The instructions informed participants that the present study entailed the participation in a roulette game with only two colours, for which they had an available budget of 20 chips. They explained that, in the first 12 rounds, sometimes the computer would decide, randomly, whether to bet on a red or black slot, and sometimes it would be the participant to decide on which colour to bet. In the first 12 rounds the bet would be always 2 chips, while at the thirteenth round the participant could decide how much to bet.
Once read the instructions, the participant could press the "Next" button to begin the experiment.

Each of the first 12 rounds consisted of two phases. In the first one, a screen was presented showing a Graphics Interchange Format image of a roulette wheel rotating with a white ball on the inside ball track. In this phase, a phrase appeared on the screen informing whether the computer or the participant would decide the slot colour on which to bet. In the first case, the phrase “In this round, the computer will decide the bet. The computer bets on red/black” appeared; in the second one, the phrase “In this round, you will choose your bet. What do you want to bet on?” appeared and the participant had to select red or black slot colour.

By pressing the "Next" button, the participant went to the second phase. In this phase, a second screen appeared showing an image with the choice outcome, accompanied by the phrase "The ball landed on the red (or black) slot. You have earned (or lost) 2 coins". The second screen also informed participants about their current budget.
Both phases had no time limit. The "Next" button allowed switching to the next round.

In the first 12 rounds, the participants and the computer chose the slot color for same number of times, in a random order.

At the thirteenth and final round, participants were asked to estimate, on a scale from 1 to 100, the winning probability they would have if they personally chose what colour to bet on (*"How many probabilities to win you think you have if you choose on your own on which colour to bet? Indicate the probability, in percentage, by typing on the keyboard a number from 1 to 100")* and the winning probability if the computer chose (*"How many probabilities to win do you think you have if the computer chooses on which colour to bet? Indicate the probability, in percentage, by typing on the keyboard a number from 1 to 100).* The two questions were presented in a counterbalanced order across participants.

Subsequently, participants were asked to choose whether they wanted to let the computer make the choice of the colour on which to bet or if they preferred to choose it personally (for half participants the question was: "*Do you want the computer, randomly, to choose what colour to bet on or do you want to personally choose it?*" For the other half the question was: *Do you want to personally choose what colour to bet on or do you want the computer, randomly, to choose it?*). Participants had to choose one of the two options ("*computer"* or "*you"*).

Finally, they had to indicate, on a scale from 1 to 10, how many chips they wanted to bet ("How much would you bet from 1 to 10?").

As mentioned earlier, the outcomes of the first 12 rounds were predetermined by manipulating the number of wins and losses associated with the choices performed by the participant and by the computer, arranged to produce 4 experimental conditions.

In the first condition (*Condition 1*), the 6 participant choices resulted in 4 wins and 2 losses, while the 6 computer choices resulted in 3 wins and 3 losses: in this condition, participants in the thirteenth round had 24 chips available;

In the second condition (*Condition 2*), the 6 participant choices resulted in 2 wins and 4 losses, while the 6 computer choices resulted in 3 wins and 3 losses: in this condition, participants in the thirteenth round had 16 chips available;

In *the third condition* (*Condition 3*), the 6 participant's choices resulted in 2 wins and 4 losses, while the 6 computer choices resulted in 4 wins and 2 losses: in this condition, participants in the thirteenth round had 16 chips available;

In the fourth *(control)* condition, the outcomes of the 6 choices performed by the participant were 3 wins and 3 losses as well as the outcomes of the 6 computer choices: in this condition, participants at the thirteenth round had 20 chips available.

At the end of the three experiments, participants completed, in a counterbalanced order, the BIS-11 and BSSS. Finally, they completed the SOGS. The three scales used will be described below. Note that the description will not be repeated in the other two studies.

The Barratt Impulsiveness Scale (BIS-11), used in the Italian version validated by Fossati et al. (2001) is a scale evaluating the tendency to impulsivity in three areas: motor impulsivity, impulsivity without planning, cognitive impulsivity. It consists of 30 items rated on a 4-point Likert scale (from 1 = never / rarely to 4 = almost always / always): total score ranges from 30 to 120.

The Brief Sensation Seeking Scale (BSSS), used in the Italian version validated by Primi et al. (2011), is a one-dimensional scale evaluating the tendency to *sensation seeking*[24].

[24] Hoyle et al. (2002) developed the BSSS by selecting 8 items from the original SSS-V scale of Zuckerman et al. (1964), according to which sensation seeking was conceptualized as the search for intense, complex, new and varied experiences and sensations as well as the willingness to assume financial, legal, social and physical risks for such experiences.

It consists of 8 items rated on a 5-point Likert scale (from 1 = "completely disagree" to 5 = "totally in agreement"): total score ranges from 8 to 40.

The SOGS is a questionnaire composed of 16 items: scores are obtained by summing up the number of questions that point to a risky response. The score rating ranges from 0-2 (no problem) to 3-4 (problematic and at risk) to 5 or more (pathological gambler).

In order to carry out the experiment, it was used a laptop computer with which data was collected. The task was implemented using Survey Monkey, an online survey development cloud-based software. The choice of this software was based on the possibility to support a Graphics Interchange Format image of a roulette wheel rotating with a ball on the inside ball track. As mentioned before, the experiment was not carry out online but rather in appropriate rooms provided by the Addiction gambling Services for all participants (problem gamblers and non-problem gamblers).

The participants took about 15 minutes to complete the experiment after which they were thanked.

Note that, after every of the three experiments, participants were thanked and that after the last one they were also accurately debriefed about the aims of the three studies. As I already wrote, during the debriefing, participants were clarified about the research hypotheses and it was ensured that they had not suspected the study purposes during the experimental session.

Results

Gambling activities

The gambling forms that were played by the problem gamblers group were assessed through the item 1 of the SOGS. In this group, the most frequently reported gambling activities were Sport betting (more than once a week: 53%), Slot machines and VLT (26%), Cards games (11%), and Lotto-Lottery-Scratchcard (10%).

Table 2 shows the gambling activity frequencies in descending order of frequency.

Table 2. Gambling activities (in percentage) reported by the gamblers group.

Gambling activity	Less than once a week	More than once a week
Sport betting	37	53
Slot machines, VLT	33	26
Cards	71	11
Lotto, lottery, scratch card	54	10
Bingo	51	4
Casino	26	4
Horse racing	18	3
Skill games	16	0
Other	7	0

Note that participants may indicate more than one form, so the total does not sum to 100%.

Preliminary analyses

In table 1 and 2 the distributions of educational level, age, BSSS and BIS_11 scores as a function of study conditions and gambling status were reported.

In order to test whether educational level was homogeneously distributed, a stratified chi-square was performed, which was not significant for both problem gamblers (χ^2 = 6.037, df = 6, p = .419) and non-problem gamblers (χ^2 = 9.455, df = 6, p = .150).

The 4 (Condition) x 2 (Gambling status) ANOVA carried out on age revealed no difference due either to Condition ($F_{3,312}$ =.481, p= .696, pη^2 = .005) or Gambling status ($F_{3,312}$ =.138, p= .711, pη^2 <.001) in the age distribution.

The same ANOVAs were performed on the two personality scales, BSSS and BIS-11.

As to the first scale, the results showed that BSSS scores were analogously distributed among the four study conditions ($F_{3,312}$ =.900, p= .442, pη² = .009) but not between problem gamblers and non-problem gamblers ($F_{3,312}$ =30.662, p< .001, pη² = .089): the former scored higher than the latter. No effect was due to Condition x Gambling status interaction.

Also the ANOVA conducted on BIS_11 showed that problem gamblers scored higher than non-problem gamblers ($F_{3,312}$ =87.383, p< .001, pη² = .219); moreover results revealed a weak but significant effect concerning the Condition ($F_{3,312}$ =2.675, p< .05, pη² = .025): pairwise comparisons with Bonferroni adjustment revealed that participants in *Condition 1* (where the participant choices resulted in 2 wins and 4 losses, while the computer choices resulted in 3 wins and 3 losses) scored higher than participants in Control Condition. The Condition x Gambling status interaction was not significant.

Table 1 – Frequency of participants in function of *gambling status* and *conditions*. Percentages indicate the distribution of each education level within the two groups.

		Condition 1	**Condition 2**	**Condition 3**	**Control**	Total
Problem gamblers	*Primary-middle school*	9 (37.5%)	4 (16.7%)	6 (25%)	5 (20.8%)	24 (15.1%)
	High-school	30 (23.8%)	30 (23.8%)	31 (24.6%)	35 (27.8%)	126 (79.24%)
	Degree	1 (11.1%)	5 (55.6%)	3 (33.3%)	0 (0%)	9 (5.66%)
Non-problem gamblers	*Primary-middle school*	8 (36.4%)	6 (27.3%)	6 (27.3%)	2 (9.1%)	22 (14%)
	High-school	30 (24.8%)	26 (21.5%)	30 (24.8%)	35 (28.9%)	121 (77.1%)
	Degree	2 (14.3%)	5 (35.7%)	4 (28.6%)	3 (21.4%)	14 (8.9%)

Table 2 – means (and s.d.) of participants'age, BSSS and BIS-11 scores as a function of the experimental conditions and gambling status.

	Condition 1	**Condition 2**	**Condition 3**	**Control**
AGE				
Problem gamblers	34.5 (11.8)	35.18 (10.51)	33.45 (9.26)	33.75 (11.38)
Non-problem gamblers	35.03 (11.13)	34 (9.95)	32.63 (9.3)	33.48 (10.59)
BSSS				
Problem gamblers	23.23 (6.06)	25.08 (6.35)	22.23 (4.36)	22.7 (4.82)
Non-problem gamblers	19.12 (6)	19.78 (5.27)	21 (5.71)	19.7 (5.11)

BIS-11				
Problem gamblers	64.72 (11.24)	60.28 (11.28)	58.57 (10.74)	58.9 (7.77)
Non-problem gamblers	51.45 (9.12)	49.85 (8.69)	51.98 (9.59)	49.02 (7.63)

Inferential analyses

As suggested by one of the two reviewers, Prof. Luke Clark, all statistical analyses were firstly performed without any covariates. Then the two covariates, i.e. *BSSS* and *BIS-11* scores, were included in the analyses in order to examine their potential impact on the results. The same procedure has been adopted in all the three studies.

I will report the results of the analyses without covariates. Only when the results of two types of analyses differed, I will report both results.

First, the effects of the independent variables - *Condition* (1 vs. 2 vs. 3 vs. control) and *Gambling status* (problem gamblers vs. non problem gamblers) - on each of the three dependent variables (*winning probability estimates* of each of the two selection modes of the slot colour, preference for the *choice* - personal or made by the computer - of the colour on which to bet, and *bet amount*) were tested, without and with covariates. Then, mediation analyses were performed to examine whether *winning probability estimates* and *choice* mediated the effect of the independent variables on *bet amount*.

Probability

In order to examine the incidence of the two independent variables on participants' probability estimates, a 4 (*condition:* 1 vs. 2 vs. 3 vs. control) x 2 (*gambling status*: problem gamblers vs. non-problem gamblers) x 2 (*probability*: you and pc) mixed ANOVA was performed. The between-subjects variables were *condition* and *gambling status.* The within variable was *probability estimate* (2 levels: *you vs. pc).*

Results showed a main effect of *Probability*, $F_{1,312} = 30{,}84$; $p < .000$; $p\eta^2 = .09$: participants estimated *you probability* (51.31%) to be higher than *pc probability* (45.16%). This effect was moderated by *Condition*, as revealed by the two-way interaction, *Condition x*

Probability, $F_{3,312} = 3.016$; $p < .05$; $p\eta^2 = .028$, which was examined through simple effects analysis with Bonferroni adjustment for multiple comparisons. Pairwise comparisons showed that in almost all conditions, *you probability* was higher than *pc probability* (all ps < .001). Only in the *condition 3*, in which the participants' choices were mainly losing while those of the computer were mainly winning, the two probability estimates did not significantly differ (p = .693). These results did not vary when the two covariates were introduced in the model and an ANCOVA was carried out, after checking that there were no interactions between covariates and independent variables, in conformity with the assumption of homogeneity of regression slopes.

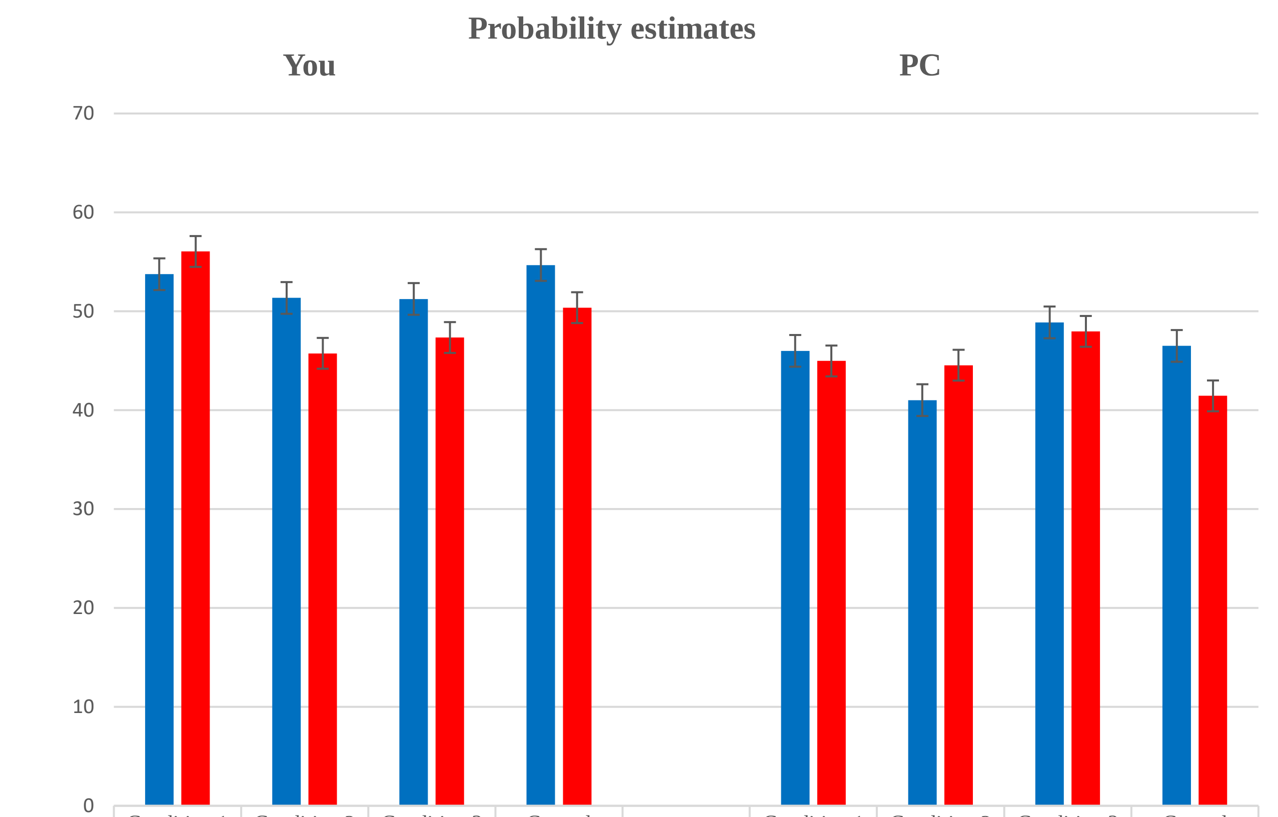
Furthermore, in order to detect potential collinearity between independent variables and covariates, a multiple linear regression was performed, in which the two repeated dependent variables were transformed in a single variable, *probability delta*, calculated by subtracting *pc probability* from *you probability.* The multicategorical independent variable, Condition, was coded as three dummy variables (Condition 1 = 1; other conditions = 0 / Condition 2 = 1; other conditions = 0 / Condition 3 = 1; other conditions = 0) with control condition as reference category[25]. The other predictors entered in the model were *gambling status* (1 = problem gamblers; 0 = non-problem gamblers) and *BSSS* and *BIS-11* scores. Results showed that, compared to the control condition, in Condition 3 probability delta decreased (B= -7.595; SE = 3.15; t = -2.412; p <.05). In line with previous results, in condition 3, in which the participants' choices were mainly losing while those of the computer were mainly winning, the difference between the two probabilities decreased, while in the other two conditions it did not differ from the control one (where *you probability* was higher than *pc probability*). The VIF values ranged from 1.314 to 1.537, which indicates the absence of multicollinearity problem (Hair, Anderson, Tatham, & Black, 1998).

Graphic 1 shows the participants' probability estimates in the study conditions.

Graphic 2 shows the Probability x Condition interaction.

[25] The three dummy variables were the following:
condition 1: you(4wins+2losses)+pc(3wins+3losses);
condition 2: you(2wins+4losses)+pc(3wins+3losses);
condition 3: you(2wins+4losses)+pc(4wins+2losses).

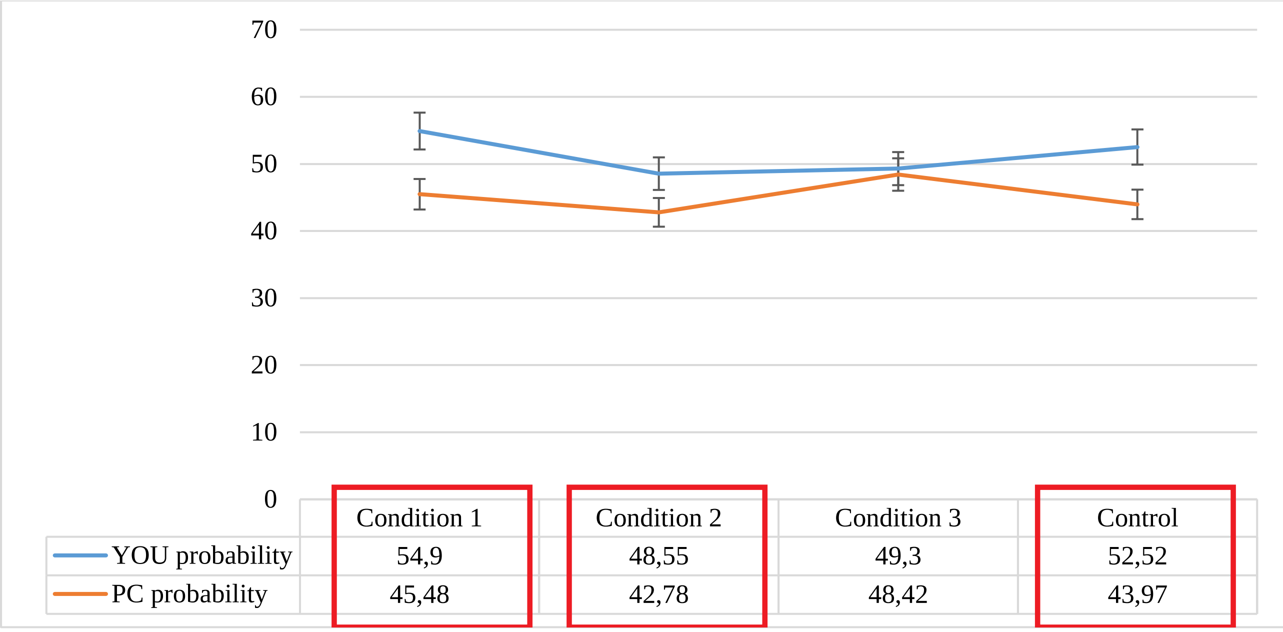
Graphic 1. Means (with SD in bars) of participants' probability estimates as a function of the study conditions (PG= problem gamblers; NPG=non-problem gamblers).



	You: Condition 1	You: Condition 2	You: Condition 3	You: Control	PC: Condition 1	PC: Condition 2	PC: Condition 3	PC: Control
NPG	53,75	51,35	51,25	54,68	46	41,02	48,88	46,5
PG	56,05	45,75	47,35	50,37	44,98	44,55	47,97	41,45

Condition 1: you(4wins+2losses)+pc(3wins+3losses). Condition 2: you(2wins+4losses)+pc(3wins+3losses). Condition 3: you(2wins+4losses)+pc(4wins+2losses); Control: you(3wins+3losses)+pc(3wins+3losses).

Graphic 2: Means (with SD in bars) of the *two probability estimates* as a function of the C*ondition x Probability* interaction

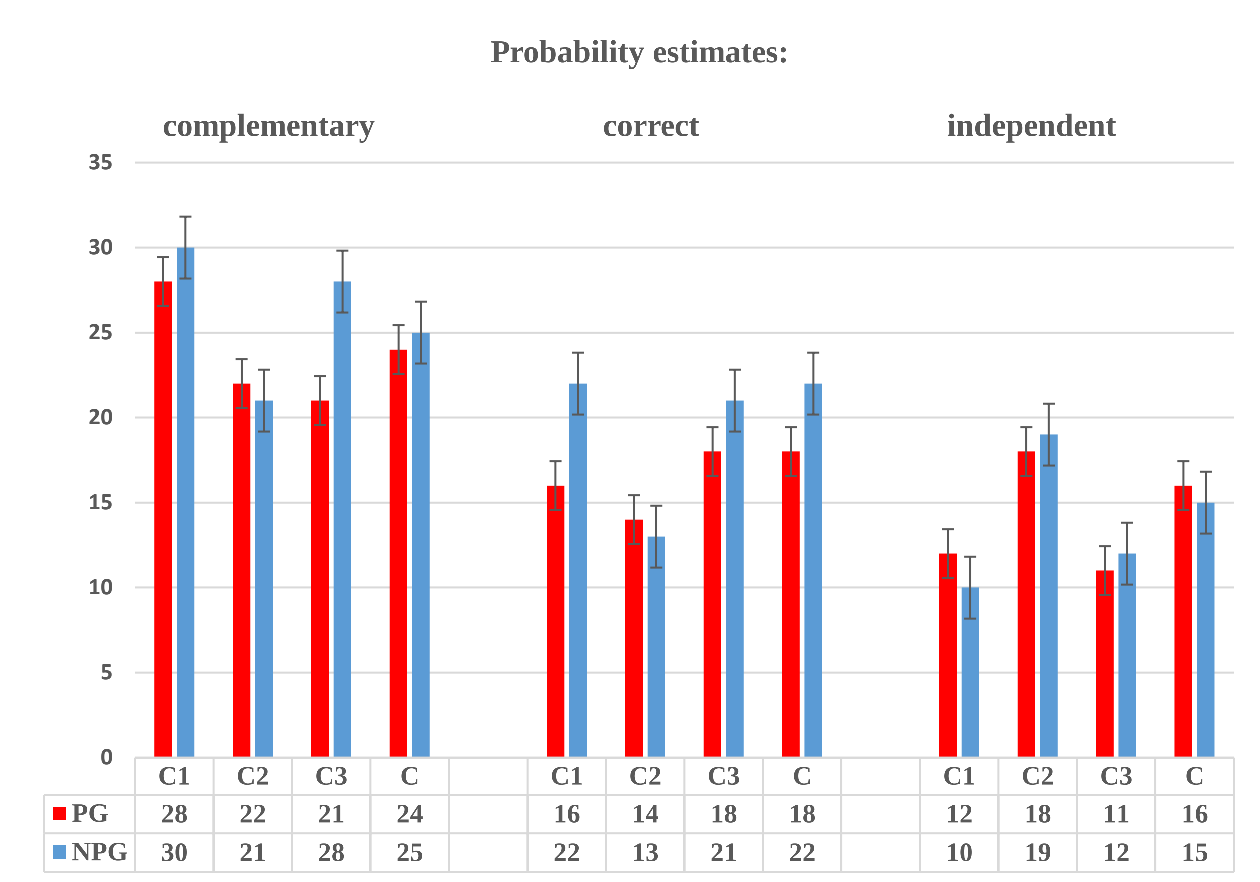


Condition 1: you(4wins+2losses)+pc(3wins+3losses). Condition 2: you(2wins+4losses)+pc(3wins+3losses). Condition 3: you(2wins+4losses)+pc(4wins+2losses); Control: you(3wins+3losses)+pc(3wins+3losses).

To investigate whether the participants perceived *you probability* and *pc probability* as complementary or independent from each other as a function of experimental conditions and gambling status, three chi-squares were performed on the following variables, calculated *ad hoc*: a) the number of cases where the sum of the two probabilities in percentage was equal to 100 (i.e. for which the two probabilities were complementary); b) the number of cases where each of the two probabilities was equal to 50 (i.e. those giving correct probabilities); c) the number of cases where the sum of the two probabilities was different from 100 (i.e. for which the two probabilities were independent from each other)[26]. None of the results was statistically significant: neither the experimental condition nor the gambling status affected participants' conceptions of probability[27]. In graphic 3 the distribution of the three types of probability conceptions in function of the independent variables were reported.

[26] Note that the cases in group b) were a sub-category of those in the group a) and that the sum of the cases in groups a) and c) was equal to the totality of participants.
[27] Complementary probability estimates: $\chi2$ (3) = .125, p = .989; Correct probability estimates: $\chi2$ (3) = .276, p = .965; Independent probability estimates: $\chi2$ (3) = .276, p = .965.

Graphic 3. Distribution of the three types of probability conceptions in function of the independent variables:



	complementary C1	complementary C2	complementary C3	complementary C	correct C1	correct C2	correct C3	correct C	independent C1	independent C2	independent C3	independent C
PG	28	22	21	24	16	14	18	18	12	18	11	16
NPG	30	21	28	25	22	13	21	22	10	19	12	15

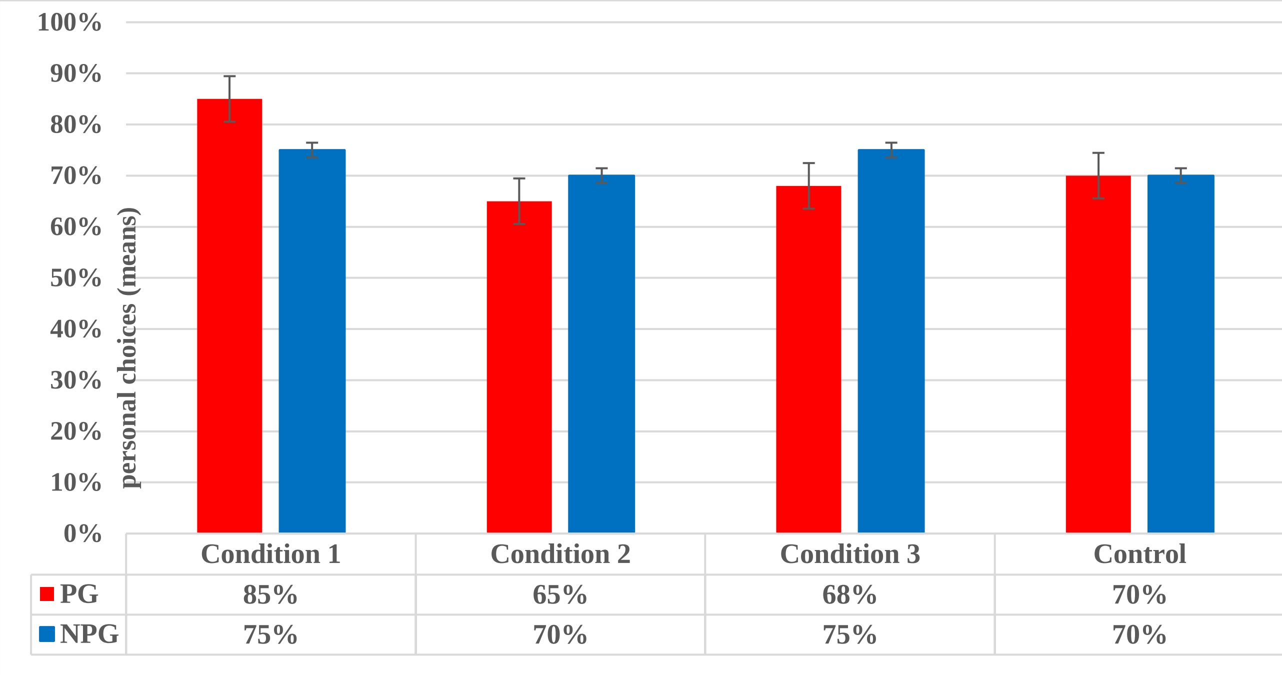
Legenda: PG = problem gamblers; NPG = non-problem gamblers. C1 = Condition1: you(4wins+2losses)+pc(3wins+3losses); C2 = Condition2: you(2wins+4losses)+pc(3wins+3losses); C3 = Condition 3: you(2wins+4losses)+pc(4wins+2losses); C = Control condition: you(3wins+3losses)+pc(3wins+3losses).

Choice

In order to assess the incidence of the two independent variables on the participants' preference for the agent performing the choice of the slot colour at the thirteenth round, a 4 (*condition:* 1 vs 2 vs 3 vs control) x 2 (*gambling status*: problem gamblers vs. non-problem gamblers) between-subject ANOVA was performed. Choice was coded as a dummy variable (1 = personal choice; 0 = computer choice); so, ANOVA was performed on the proportion of the personal choices.

Graphic 4 shows the distribution of the personal choices made by the two participants' groups at the 13th round.

Graphic 4. Percentage (with SD in bars) of the personal choices as a function of the study conditions (PG= problem gamblers; NPG= non-problem gamblers).



Condition 1: you(4wins+2losses)+pc(3wins+3losses). Condition 2: you(2wins+4losses)+pc(3wins+3losses). Condition 3: you(2wins+4losses)+pc(4wins+2losses); Control: you(3wins+3losses)+pc(3wins+3losses).

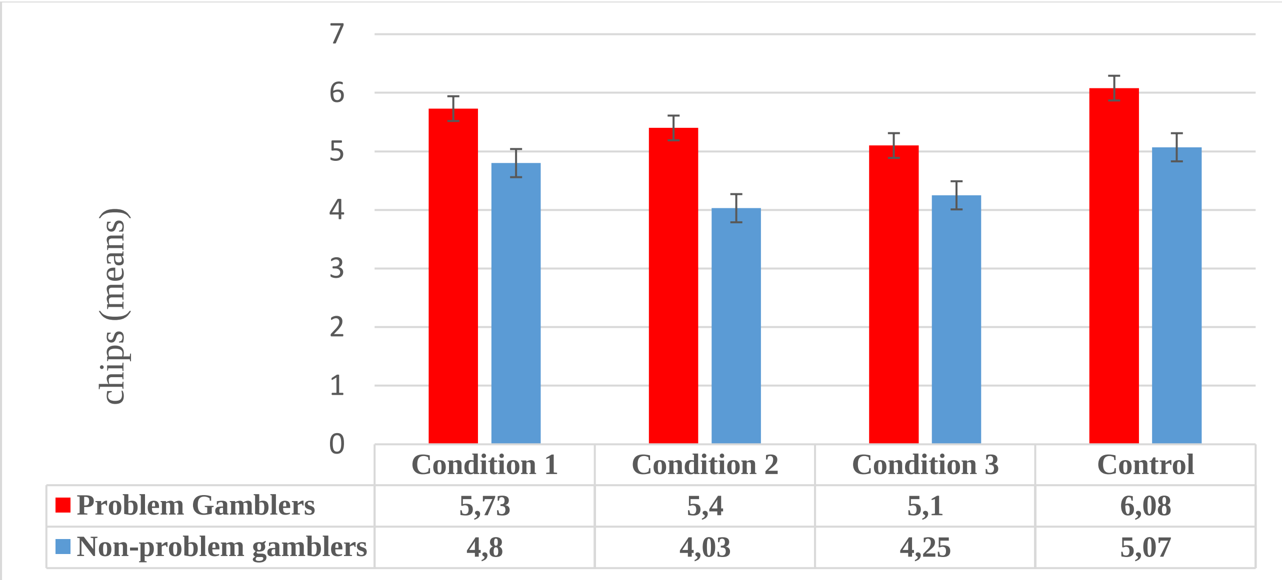
No statistically significant effects emerged from the results: independently of the study conditions, the personal choice was always predominant. The same results were obtained from ANCOVA.

Bet amount

To assess the incidence of the two independent variables on the bets carried out by participants, a 4 (*condition:* 1 vs 2 vs 3 vs control) x 2 (*gambling status*: problem gamblers vs non-problem gamblers) between-subjects ANOVA was performed. The dependent variable was the *bet amount*.

Graphic 5 shows the participants' bets in the study conditions.

Graphic 5. Means (with SD in bars) of participants' bets as a function of the study conditions.



Condition 1: you(4wins+2losses)+pc(3wins+3losses). Condition 2: you(2wins+4losses)+pc(3wins+3losses). Condition 3: you(2wins+4losses)+pc(4wins+2losses); Control: you(3wins+3losses)+pc(3wins+3losses).

Results revealed a main effect of the *Gambling status*, $F_{1.312} = 19.196$; $p < .001$; $p\eta^2 = .058$: problem gamblers, regardless of experimental conditions, betting more (5.57) than non-problem gamblers (4.53). They also revealed a main effect of the *condition*, $F_{3,3129} = 3.419$; $p = .05$; $p\eta^2 = .032$. LSD pairwise comparisons showed that participants in the control condition bet more (5.57) than those in the conditions 2 (4.71) and 3 (4.67), where personal choices were predominantly losing. No difference was found between the control condition and the condition 1 (5.26), in which personal choices were predominantly winning. Similar results were found with the ANCOVA.

Effect of the experimental conditions on the choice via probability estimates

To investigate whether the experimental condition affected the choice via probability estimates, a mediation analysis using the PROCESS macro[28] (model 4) for SPSS (Hayes, 2013) was performed. This analysis was carried out despite the ANOVA results, showing the absence of any significant effects of the independent variables on the agent choice, in order to test a possible suppression effect of probability estimates withdrawing the relationship between the experimental conditions and the agent choice.

The multicategorical independent variable (IV) was coded as three dummy variables (Condition 1 = 1; other conditions = 0 / Condition 2 = 1; other conditions = 0 / Condition 3 = 1; other conditions = 0) with control condition as reference category[29]. Since the probability estimate was a within-subjects variable (*you probability* and *pc probability*), the probability delta was calculated, by subtracting *pc probability* from *you probability*, and introduced as potential mediator (M) (Montoya & Hayes, 2017). The choice, coded in a dummy variable (1 = personal choice; 0 = computer choice), was the dependent variable (DV). As Process macro as well as Mplus structural equation models do not allow performing a moderated mediation analysis with a multicategorical independent variable, gambling status, coded in a dummy variable (1 = problem gamblers; 0 = non-problem gamblers), was entered into the analysis as covariate, rather than as a moderator.

The macro uses bootstrapping method for estimating indirect effects (i.e. the effect of intervenient or mediating variables); 95% bias-corrected confidence intervals were calculated through 5000 bootstrap samples.

Results showed that Condition 3 affected the probability delta: compared to the Control Condition, in Condition 3 probability delta decreased ($B = -7.675$; $SE = 3.1396$; $t = -2.4446$; $p < .05$). In line with mixed ANOVA's results, in Condition 3, where the participants' choices were mainly losing while those of the computer were mainly winning, the difference between the two probabilities decreased, while in the other two conditions it did not differ from the control one. The total effects that the IV and the covariates exerted on the choice were not significant, in line with the mixed ANOVA results. However, when also the putative mediator

[28] The macro is retrievable from http://afhayes.com/spss-sas-andmplus-macros-and-code.html
[29] The three dummy variables were the following:
condition 1: you(4wins+2losses)+pc(3wins+3losses);
condition 2: you(2wins+4losses)+pc(3wins+3losses);
condition 3: you(2wins+4losses)+pc(4wins+2losses).

(probability delta) was included in the regression equation in order to assess the direct effect of IV on DV, the coefficient of Condition 3 increased (B = .2565) compared to that in the total effect model (B= .0603), while the coefficients of Condition 1 and Condition 2 remained analogous. So, as supposed, the effect exerted by probability delta (B = .0274; SE = .0078; z = 3.5263; p < .000) was a suppression effect rather than a mediation effect (MacKinnon et al. 2000), since its inclusion strengthened the relationship between IV and DV rather than weakened it, as does a mediator. In fact the indirect effect that Condition 3 exerted on choice via probability delta (B = -.2103; SE = .1008, 95% CI = -.4726, -.0581) had a negative sign[30], opposite to the positive sign of the direct effect (B = .2565; SE = .3564, z = .7198; p = .4716; 95% CI = -.4419, .955) (MacKinnon et al. 2000). So, the opposite directions of direct and indirect effects strongly weakened the total effect of Condition 3 on personal choices compared to that of the control condition.

The mediation analyses considering in the model also the BSSS and BIS-11 scores as covariates showed analogous results.

Effect of the experimental conditions on the bet amount via probability estimates and choice

To investigate whether the experimental conditions affected the bet amount via probability estimates and choice, two separate analyses were needed. As neither Process macro nor Mplus structural equation models allow a dichotomous mediator (i.e. choice), the following analyses were performed: a first mediation analysis to test whether the experimental conditions affected the bet amount via probability estimates, and a multiple regression analysis, in which choice was included among predictors.

The mediation analysis was similar to the one above described: the only difference was that the dependent variable (bet amount) was continuous, not dichotomous. The effect of the IV on the probability delta was already described: compared to the reference category (i.e. control condition) in the Condition 3 probability delta decreased. The total effects of the IV

[30] The negative sign of the indirect effect (i.e. the product of the effects of IV on M and of M on DV) was due to the fact that in Condition 3 the probability delta (M) was reduced compared to the Control Condition (and the other conditions), whereas the increase of probability delta (M) increased personal choice.

and the covariates were in line with those emerged from ANOVA: compared to the control condition, bet amount decreased in Condition 2 (B = -.8625; SE = .3337; t = -2.5849; p < .05) and in Condition 3 (B = -.9000; SE = .3337; t = -2.6972; p < .005); problem gamblers bet more than non-problem gamblers (B = 1.0375; SE = .2359; t = 4.3972; p < .000). When also probability delta was entered in the regression equation to test the direct effects of IV on the DV, the results were the following: probability delta significantly increased the bet amount (B = .0132; SE = .006; t = 2.2137; p < .05); the direct effects of Condition 2 (B= -8258; SE = .332; t = -2.487; p < .05) and Condition 3 (B= -7989; SE = .3348; t = -2.3865; p < .05) still remained significant but the effect of Condition 3 slightly decreased compared to the total one, consistent with a partial mediation effect of probability delta[31]. In fact, Condition 3 exerted an indirect negative effect on the bet amount through probability delta (B = -.1011; SE = .0678; 95% CI = -.2775, -.0068), with the same sign as that of the direct effect. Although Conditions 2 and 3 directly (i.e. after controlling for the probability delta) affected the bet amount by diminishing it, part of the effect of Condition 3 was exerted indirectly, through the mediation of probability delta.

Subsequently, a multiple linear regression was performed entering the three dummy Conditions, gambling status, delta probability and choice as predictors of the bet amount. The results showed that, in line with previous analysis, compared to the Control Condition, Condition 2 (B= -.817; SE= .328; t= -2.488; p < .05) and Condition 3 (B= -.837; SE= .331; t= -2.527; p < .05) decreased the bet amount and that problem gamblers bet more than non-problem gamblers (B= 1.023; SE= .232; t= 4.4; p < .000). However, the effect of delta probability was no longer significant (B= .01; SE= .006; t= 1.579; p = .115), whereas choice increased significantly the bet amount (B= .77; SE= .266; t= 2.895; p < .005). These results revealed that the inclusion of choice in the regression equation faded the effect of delta probability, suggesting that the latter could exert its effect on bet amount via choice. However, since it was not possible to test a mediational model with two mediators in series (because choice was a dichotomous variable), the putative indirect effect of probability delta on the bet amount trough choice was not assessed. It should be noted that the coefficients of Condition 2 and 3 in the last multiple regression, in which also choice was entered, were similar to those

[31] The direct effect of gambling status de was similar to the total one (B= 1.011; SE = .2348; t = 4.3057; p < .000).

of the mediational model without choice, thus indicating the probable absence of mediation exerted by this variable.

Once again, the analyses conducted by introducing also the BSSS and BIS-11 scores as covariates in the model showed the same effects above reported.

Discussion and conclusions

The present study investigated the putative existence of the illusion of control in problem gamblers and non-problem gamblers, examining whether previous outcomes associated with *personal* and *random* choices in a gambling task influenced (i) the winning probability estimate linked to personal or random choice of the next event to bet on, (ii) the selection of the choice-agent, and (iii) the bet amount. A specific aim of the study was to examine whether problem gamblers and non-problem gamblers behaved in similar or different ways in relation to such factors. As it has been written in the overview of the study, contrasting hypotheses concerning the study goals were tested.

More specifically, it was expected that if participants were prone to the illusion of control they should believe that, choosing personally the color on which to bet, they should have more possibilities to win compared to the random choice made by the computer. If they were not affected by the illusion of control but only preferred personal agency, the probability estimates would be correct but the predominant choice would be the personal one. If they were subject to the influence of previous outcomes, then they should believe that the winning probability associated with the personal choice and with the computer-made choice varied depending on experimental conditions: so, they should prefer to choose themselves in the condition in which personal choices are predominantly winning and let the computer choose in the conditions where the computer choices are predominantly winning.

Concerning the hypotheses on betting, it was expected that if the bet amount varied in function of the experimental conditions (i.e. it increased following the “winning” conditions and decreased following the “losing” ones), people would be subject to the influence of previous outcomes. On the contrary, betting more in case of overestimation of winning probabilities linked to personal choices would be an index of illusion of control. Also betting more after personal choice (without overestimating personal winning probabilities) was considered an indicator of the illusion of control, since such behaviour suggested that positive outcomes were expected by personal rather than random choices.

Finally, in conformity with several evidences in the literature, it was expected that problem gamblers were more prone than non-problem gamblers to the illusion of control and that problem gamblers and the participants scoring higher on sensation-seeking and/or impulsivity scales would made higher bets.

The results pointed out that the participants, regardless of their gambling status, showed both a preference for agency and the illusion of control. Indeed, in conformity with the *preference for agency* hypothesis, in all experimental conditions, regardless of the number of wins and losses due to the personal or computer choices, people preferred to choose personally the colour on which to bet instead of entrusting the choice to chance. In addition, in line with the illusion of control hypothesis, in almost all conditions, the participants tend to attribute higher winning probabilities to the personal choice than the one left to the computer. The only exception is represented by the condition in which the personal choices mostly resulted in losses whereas the ones made by the computer were mainly winnings (Condition 3), where the two probability estimates are analogous. In this case, the participants seemed to show a preference for agency rather than the illusion of control. In fact, in this condition, the *connection* between an action and its outcome, and the *intention* to achieve the expected outcome - that is, the two features that according to Thompson et al. (1998; 2004) underlie the control heuristic - seem to be absent. Consequently, the connection between one's actions and the desired outcome (winning) is not perceived. However, in the condition where personal choices mostly resulted in losses, whereas the ones made by the computer were balanced between wins and losses (Condition 2), the connection is still perceived, proving the strength of the illusion of control[32].

The picture so far described becomes more complex in the light of the results emerged by the mediational model performed to investigate the relationship between experimental conditions, the winning probability estimates attributed to oneself and to computer, and the selection of the choice-agent. On the one hand, the results showed that the higher the

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[32] A result that raises doubts about this interpretation will be discussed later, concerning the bet amount.

difference between the two probability estimates, the more frequent were personal choices than the computer-entrusted ones. On the other, they revealed that concerning Condition 3, where the difference between the two winning probability estimates (compared to the other conditions) reduced, the probability delta (i.e. the difference between the winning probabilities attributed to personal choice and those attributed to computer random choice) had a suppression effect on the relationship between such condition and the choice. When this effect is not controlled for, the total effect of Condition 3 on choice is weakened and becomes analogous to those of the other experimental conditions.

The results of the analyses conducted on the bet amounts partly question the extent of the illusion of control, or at least, the extent of its effect on decision-making. In fact, the participants bet less in conditions 2 and 3, where personal choices were predominantly losing, than in control condition, where personal and computer choices were equally distributed in wins and losses. As regards the condition 3, the mediation analysis showed that this effect was partly mediated by the probability delta decrease in such condition. Overall, the results of the mediation analysis and of the multiple regression, in which the effect of all predictors (conditions, gambling status, delta probability, impulsivity and sensation-seeking scores, age, and choice) on the better amount was assessed, showed two effects going in opposite directions: personal choice (through which the effect of probability delta was exerted)[33] increased the bet amount, whereas conditions 2 and 3 (where personal choices were predominantly losing) decreased it. So, these findings suggest that people are prone to the illusion of control from a cognitive point of view (i.e. in estimating winning probabilities), whereas are also influenced by previous outcomes from a behavioral point of view (i.e. in deciding how much to bet). This finding is in line with the studies (e.g. Charness & Gneezy, 2010; Grou & Tabak, 2008) showing that the preference for agency did not entail increased bet amounts: in case of personal selection, participants' bets did not differ from the ones made when it was the experimenter who selected the numbers on which to bet. Moreover it is also in line with the study of Chau and Phillips (1995), conducted on a sample of non-problem

[33] Although the data features impeded to test a three-path mediational model with two mediators (probability delta and choice) in series, the results of multiple regression analysis suggest that the probability delta affected the bet amount through personal choice.

gamblers, where participants adjusted their bet size in a computer blackjack according to the previous outcomes.

In the present study, the differences due to the gambling status were that problem gamblers bet more than non-problem gamblers and that problem gamblers scored higher than non- problem gamblers on the sensation-seeking and impulsivity scales. Nevertheless no effect has been exerted by the two personality scales on any of the dependent variables and no difference has been found between the two groups regarding the proneness to the illusion of control. So, one must acknowledge that the results of this study do not corroborate the widely shared assumptions that problem gamblers are particularly prone to cognitive distortions, such as the illusion of control, and that specific personality factors, such as higher levels of impulsivity and sensation-seeking, make people more subject to the illusion of control and to related behaviors, such as the increase in bet amount (Davis et al., 2000; Griffiths, 1994; Lim et al. 2015; Ladouceur & Walker, 1996; Michalczuk et al. 2011; Miller & Currie, 2008; Myrseth et al. 2010; Nower et al., 2004; Petry, 2001; Romo et al., 2016). However the only study that, to my knowledge, compared the extent of the illusion of control in problem gamblers and non-problem gamblers with a contingency judgment task (Orgaz, Estévez, & Matute, 2013) found that problem gamblers overestimated their control more than non-problem gamblers but that the behaviour of the two groups in decision-making did not differ.

Finally, it should be noted that asking participants to estimate the winning probabilities attributed both to personal and the computer choice has allowed to establish that, regardless of experimental conditions and gambling status, only 207 participants out of 320 considered the two probabilities complementary (and only 144 evaluated them correctly), while the remaining 113 considered the two probabilities as reciprocally independent.

To the best of my knowledge, no previous study investigated the winning probability estimates associated with the two options of agent-choice in problem gamblers and non-problem gamblers. Even in Dixon’s study (2000) where, at the end of the game session, problem gamblers were asked to estimate the winning probabilities, both whether the choice was made personally and by the experimenter, the overestimation of winning probabilities was in function of the presentation of accurate/inaccurate information. However, the (small) sample of problem gamblers was not compared to a control one.

In conclusion, as mentioned before, in the present study participants' bets were more dependent from previous outcomes rather than probability estimates. Such results suggests that people, regardless of their gambling status, seem to be keener on taking into account past experiences from a behavioral point of view, rather than a cognitive one.

CHAPTER III

The gambler's fallacy and the hot hand fallacy in problem gamblers and non-problem gamblers

Gambling involves a succession of independent events. Sequences of lottery extractions, roulette draws or slot machine games are prototypes of random events unrelated from one other. However, numerous studies showed that people, when asked to make predictions on random sequences of events, may ignore the mutual independence relationship between them (Tversky & Kahneman, 1971, Kahneman, & Tversky, 1972, Gilovich, Vallone and Tversky, 1985; Xue et al., 2012; Studer, Limbrick-Oldfield & Clark, 2015). In these cases, people mistakenly believe that a random sequence of events may influence the outcome of the next ones. Such beliefs can give rise to two opposite phenomena.

The first is the *gambler's fallacy* (or Monte Carlo's fallacy), i.e. the belief that a succession of identical cases will be followed by an opposite event (*negative recency*). This phenomenon was discovered in the studies on the perception of randomness (Tversky and Kahneman,1971; Kahneman and Tversky, 1972; Wagenaar, 1972) where people, in recognizing and generating random sequences (heads or tails in a "flip of a coin"), preferred sequences not having a long series of the same outcome or sequences in which randomness was equated by balancing event frequencies.

As opposed to the gambler's fallacy, the *hot hand fallacy* is the belief that events correlate positively between them. In this case, people expect an outcome to be in line with the previous sequence of events (*positive recency*) instead of being opposed to it. This phenomenon was observed for the first time by Gilovich et al. (1985), who showed that people predicted that basketball players, after 5 consecutive winning scores, would score on the next throw, as they believed the player had, in fact, the "hot hand".

3.1. Theoretical interpretations and empirical evidence

Although the two fallacies rely on opposite predictions (on the one hand, the inversion and, on the other, the continuation of outcomes), both of them have been theoretically associated with the *heuristics of representativeness* (Tversky & Kahneman, 1971; Kahneman, & Tversky, 1972; Rabin, 2002) and the *law of small numbers*. According to this hypothesis, people expect even a short random sequence to be representative of the event distribution in wider random sequences. Therefore, in the case of the gambler's fallacy, in front of a sequence of identical events that does not reproduce the personal representation of randomness, people tend to believe that in the future this sequence will be balanced by events of the opposite outcome. Differently, in the case of the hot hand fallacy, in front of a sequence of events that do not match own randomness expectation, people tend to attribute it to the agent's ability (to his "hot hand") instead of recognizing it as random.

However, a wide corpus of research, mainly conducted with healthy individuals, has attempted to disentangle the factors responsible for the occurrence of one or the other fallacy. Nevertheless, to date, explanatory hypotheses and empirical evidence are discordant. Ayton & Fisher (2004) assumed that the expectation about the nature of events could be the discriminating factor between the two fallacies. According to this assumption, events related to human performance would be more controllable and less casual than inanimate events; therefore, the first ones would elicit the hot hand fallacy while the second ones the gambler’s fallacy. In the first experiment, participants were asked to make predictions on the outcomes of a random binary sequence (red and black on a computerized roulette) and to indicate the level of confidence in the success of their predictions. The results showed that they made predictions in line with the gambler's fallacy, and that confidence levels increased with the number of predictions having a positive outcome. In the second experiment, participants were presented with three sets of events, each consisting of a series of binary sequences varying in recency, and were asked to identify, for each set, the type of processes - human skilled performance vs. random sequence - to which the events belonged. According with the authors’ predictions, participants attributed the sequences with fewer alternations to human performance, while those with greater alternation to random processes.

Similarly, the study by Burns & Corpus (2004) showed that predictions about future events were in line with the gamblers' fallacy or the hot hand fallacy as a function of the perceived randomness of the scenarios in which those events were embedded. In this study, the degree of randomness of several scenarios was manipulated and, for each of them, participants were asked to predict the next event between two possible ones, to estimate the probability that this event would represent the continuation of a sequence, and to indicate (on a 6-point scale) the degree of randomness of that event. The results showed that the more participants perceived the scenarios as random, the more their responses were in line with the gambler's fallacy; on the contrary, when scenarios were perceived as less dependent on the chance, responses tended to be conform to the hot hand's fallacy.

Previously, three studies of Boynton (2003) indicated that the occurrence of the hot hand fallacy vs. the gambler's fallacy was associated, respectively, with prior successes or failures in predicting future events in a sequence. For example, in the experiment 2, participants were presented with a binary sequence of two symbols (a red circle or a blue square), in which the pattern of the last three outcomes was varied as a function of the number of occurrences of the same outcome. In 100 trials, participants had to guess which symbol would appear on the computer screen and to indicate the confidence level in their predictions. Moreover, in the experiment 3, they also had to provide randomness judgments about the sequence. Overall, the results showed that, regardless of randomness judgements, the predictions were related to the success or failure in the previous trial and were not influenced by a preference for either of the two stimuli. They suggested a "positive recency" effect (in line with *hot hand fallacy*) after successes, interpretable, from a behavioural point of view, as a mere tendency to repeat the reinforcement-receiving responses, therefore producing a "win-stay strategy". On the contrary, after failures, participants did not merely adopt the opposite "lose-shift" strategy, but rather relied both on recency and frequency (run length) information, leading to the production of the gambler's fallacy with long runs of the same outcome.

By stressing the different cognitive complexity of the two fallacies, these findings are in line with the explicative hypothesis of the two phenomena proposed by Braga et al. (2013), based on the cognitive load required by the processes underlying each of them. According to this hypothesis, the hot hand fallacy, being a simpler process based on the continuation of a sequence, would be related to the availability heuristic. This heuristic, relying upon knowledge that is easily retrievable, would require lesser cognitive resources than the representativeness heuristics, which demands a judgment of similarity between an event and a category, and which has been considered at the basis of the gambler's fallacy, where an overturn is expected. In their study, the cognitive load was manipulated by varying the degree of time pressure under which participants had to make a choice (predicting the outcome of a binary sequence as a coin flip). The results showed that participants predicted, in line with the *hot hand fallacy*, a continuation of the sequence under strong pressure, and, in line with the *gambler's fallacy,* more alterations in conditions of lower temporal pressure.

A somewhat different interpretation had been proposed by Caruso et al. (2010) according to which predictions about the next event in a sequence depends on the degree of perceived *intentionality* of the agent generating the sequence: the more a sequence is perceived as intentional, the more people predict its continuation. In the first experiment, the participants were informed that a sequence of dice throw had been performed by a professional player (intentional condition) or by chance (unintentional condition) and had to predict the next outcome. The results showed that participants in the intentional condition predicted a continuation of the sequence more frequently than those who assessed in the unintentional condition. In the second experiment, craps sequences ending with a series of identical or random outcomes were presented via video in a counterbalanced order. The results revealed that participants instructed to focus on the agent's purpose (intention condition) made predictions in line with the hot hand fallacy, while those instructed to focus on physical movements (action condition) tended to make predictions in line with the gambler's fallacy. The other two experiments showed that the participants more prone to represent actions in terms of intentions (third experiment) or to attribute mental states to inanimate agents (fourth experiment) predicted more likely the continuation of a sequence to be more likely. Moreover, this study showed that the perception of intentionality also affected the probability estimate of the next event in a series. In the first experiment, after the presentation of a manipulated sequence of 12 dice rolls (ending with three consecutive outcomes of the winning number), participants were asked to predict the next outcome and to indicate (on a 7-point Likert scale) the probability of each die face being extracted. The participants in the "intentional condition" overestimated the extraction probability of the winning number whereas those in the control condition did not.

A different interpretation of the two fallacies derives from the evolutionary perspective (Wilke & Barrett, 2009; Scheibehenne et al., 2011; Wilke et al., 2014). According to this perspective, the hot hand phenomenon would be, rather than a fallacy, an evolved default assumption that environmental resources tend to be distributed in clumps rather than randomly. On the other hand, the gambler's fallacy would take place within a system involving resource depletion (Wilke & Barrett, 2009). The empirical support about the evolutionary basis of the hot hand phenomenon derives from the Wilke & Barrett's (2009) study, where two groups belonging to different populations (American students and Shuar residents) predicted the presence/absence of natural (fruits, bird's nests) and artificial (car parks, bus stops, flip a coin) resources in random binary sequences. Although the predictions of both groups showed a "positive recency" effect over all types of resources (with more robust effects on natural resources), this effect was reduced into the coin flip predictions of the Americans' group that, unlike the Shuar residents, was familiar with the casual properties of this game.

To my knowledge, no direct investigation about the gamblers' fallacy has been carried out from this perspective.

Instead, the studies performed by varying the length of a run found more evidence for the gamblers' fallacy than for the hot hand fallacy. For example, in the field study of Dohmen et al. (2009) conducted on a sample of 1000 subjects living in Germany, participants were invited to imagine a sequence of eight coin flips and to estimate the probability of occurrence of an outcome opposite to the last imagined. The results showed that about 21% overestimated the probability of occurrence of the opposite event (in line with gambler's fallacy), while about 9% indicated a probability estimate below 50% (in line with the hot hand fallacy). The correct probability estimates were provided by about 60% of participants.

More recently, Studer et al. (2015) presented participants with a computerized roulette consisting of two colors. After varying the length of a sequence of identical outcomes, participants were asked to predict the next outcome and to express the level of confidence in their choice. In line with the gambler's fallacy, the choice of an outcome identical to the last presented reduced as a function of the run length. In addition, confidence in their choices also increased as a function of the length of the sequence, with the highest levels associated with the choices in line with the gambler's fallacy. Instead, regardless of the sequence length, confidence levels were higher after a win than after a loss. Finally, when participants, after predicting the next outcome, were required to bet on its occurrence (instead of indicating the confidence level in their own choices), they made more sizeable bets when choosing the color different from that of the run (in line with the gambler's fallacy).

Finally, a study of Matarazzo and colleagues (2017) investigated whether a winning sequence of identical outcomes induced one of the two fallacies and their relationship with probability estimates and proneness to bet. After the presentation of a run of same events (high or low cards) involving a payout, participants were asked to indicate the choice of the card on which to bet, the probability estimate and how much to bet on the occurrence of such choice. Despite the presentation of a winning sequence of outcomes, participants' choices were mainly based on a *preference* (for high cards) rather than on the hot hand fallacy. They chose a card different to the last presented only when the run with the same outcome increased, in line with gambler's fallacy. In addition, as the card sequence presented did not affect the probability estimates, choice and probability seem to be two independent processes. Finally, the choice of the card was not related to the bet size, which depended on subjective winning probabilities.

3.2. The gambler's fallacy and the hot hand fallacy in problem gamblers

Whereas the abovementioned studies were performed with non-gambler participants, the following ones have been conducted with problem gamblers, in an attempt to investigate whether they were more prone to the two fallacies than non-problem gamblers. Clotfelter & Cook (1991) examined gamblers' bets at the Maryland State lottery during the extraction of 52 numbers. The results showed that gamblers acted in line with the gambler's fallacy, since the day after a number was extracted, the bets on that number diminished. Moreover, the bets on the drawn numbers tended to decrease in the three days following the extraction and to return to their average level after 84 days. Terrell (1994) obtained similar results through the New Jersey State Lottery's betting analysis.

The field studies conducted by Croson & Sundali (2005) and by Sundali & Croson (2006), investigating bets made in a casino in the state of Nevada, showed that roulette players incurred in both fallacies, also at an individual level. In fact, players who tended to bet on numbers that had not previously appeared (in line with the gambler's fallacy) also tended to bet on numbers that had recently won (in line with the hot hand fallacy[34]). Moreover, the number and the amount of bets tended to increase after winning.

Also Suetens et al. (2015), in a study on betting on Danish Lotto, found gamblers to be affected by both fallacies. In line with the gambler's fallacy, they bet to a lesser extent on the numbers drawn during the previous week but, in line with the hot hand fallacy, they also tended to bet more steadily on the numbers that had been more frequently extracted in the past.

From an evolutionary perspective, Wilke et al. (2014) presented to experienced adult gamblers and to control group (adults having only little gambling experience) two fictitious slot machines generating a binary sequence of symbols, one of which was a completely casual sequence while the other was a quite negatively autocorrelated sequence, exhibiting higher alternation probability. Participants could choose, at each trial, which of the two slot machines to bet on by guessing the next symbol. After every bet, participants received feedback about their predictions and earned some money for every correct prediction. The results showed that gamblers preferred to bet on the random sequence, which allowed to perceive more illusory patterns (in particular the positive recency effect), rather than on the sequence quite negatively autocorrelated, which instead allowed to earn more money by following a win-shift lose-stay strategy. The control group did not show any preference for one or the other sequence. Moreover, problem and pathological gamblers and non-gamblers also differed in the cognitive strategies used in betting. Although in both groups the "win-stay lose-switch" strategy (appropriate in positively autocorrelated sequences, not in the negatively correlated

[34] Sundali & Croson (2006) Sundali & Croson (2006) proposed to define as *hot-outcome* the phenomenon opposite to the gambler's fallacy. For example, after three black numbers appeared on the roulette wheel, people would believe that another black number would be more likely to appear than a red one, because the black numbers would be hot. So, differently from the hot hand fallacy, in this case the outcome (and not the individual, or his/her hand) would be hot.

ones) prevailed, gamblers tended to apply it across both sequences, whereas non-gamblers applied it only in the random sequence.

3.3. Gamblers' fallacy, hot hand fallacy, probability estimate, and betting in problem gamblers and non-problem gamblers

From a review of the literature, it seems that the studies with problem gamblers and non-problem gamblers have been conducted with quite different goals and research paradigms.

On the one hand, the studies carried out with problem gamblers mainly rely on data such as number and size of the wagers placed on a particular outcome (Clotfelter & Cook, 1991; Terrell, 1994; Croson & Sundali, 2005; Sundali & Croson, 2006; Suetens et al., 2015), implicitly hypothesizing an overestimation of the probability of the expected event. On the other hand, the experimental procedures employed in non- problem gamblers studies have mainly utilized the "what's next?" paradigm. As described, such a procedure requires, after varying the length of a sequence of identical outcomes, that participants predict the outcome of the next event (e.g. Ayton & Fisher, 2004; Xue et al., 2012; Braga et al., 2013) and eventually indicate the level of confidence in their own choice (Boynton, 2003; Clark et al., 2014; Studer et al., 2015). Only in some studies (Burns & Corpus, 2004; Dohmen et al., 2009; Caruso et al., 2010; Navarrete & Santamaria, 2011; Matarazzo et al., 2017), participants were explicitly required to estimate the probability of a target event. In other studies (Roney & Trick, 2003; Lyons et al., 2013; Marmurek et al., 2015; Studer et al., 2015), after varying the run length of identical outcomes, participants were asked to predict the next event and to bet on its occurrence, without explicitly estimating its probability[35].

Actually, there are a few studies having simultaneously investigated the multiple factors underlying the two fallacies. For example, Burns & Corpus (2004) required to predict the next outcome and to estimate its probability of occurrence, but the two indices were

[35] These studies showed that the highest bets were positively correlated with the choices made in line with the gambler's fallacy (but see Lyons et al., 2013).

separately analysed. Navarrete & Santamaria (2011) asked to estimate the winning probability when betting on a particular color in a roulette wheel[36]. Studer and colleagues (2015) asked to predict the next outcome in a series, to indicate the level of choice confidence, or the wager size.

Finally, to the best of my knowledge, so far only the study of Wilke and colleagues (2014) has compared the performance of problem gamblers and non- problem gamblers with regards to the occurrence of the two phenomena.

The present study aims to extend our previous work (Matarazzo et al., 2017) by comparing decision-making of problem gamblers and non- problem gamblers in an experimental setting designed to induce both fallacies.

Overview of the present study

The present study aimed to investigate, in problem gamblers and non-problem gamblers, the occurrence of the gambler's fallacy (or the hot-hand fallacy) and its relationship with probability estimates of the next outcome and the bet amount in a fictitious roulette game.

Specifically, the study pursued the following goals: 1) To investigate whether a series of identical outcomes in a roulette wheel would induce the gambler's fallacy or the hot-hand fallacy; 2) to assess whether the induced fallacy was linked to an increase in the probability estimates and in the bet amount; 3) to assess whether such effects were present to a different extent in problem gamblers and non-problem gamblers and whether impulsivity and sensation-seeking affected the participants' responses.

To this end, it was created a quasi-experiment involving a 2 x 2 x 2 between-subjects design, with three independent variables, two of which (*run length* and *run colour*) were manipulated, whereas the third (*gambling status*) was not.

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[36] In this study, the roulette set (i.e the number of available colors of the pocket to bet on) was varied. The results showed that when the task complexity increased, participants less incurred in the gambler's fallacy and provided more accurate probability estimates.

In each experimental condition, participants were invited to take part in a fictitious American roulette game (modified *ad hoc*, by excluding the two green slots associated with 0 and 00), consisting of an equal number of red (50%) and black (50%) slots where the white ball could land.

They were presented with a fictional random sequence of twelve ball throws, in which the ball could land on a red or a black slot. At the thirteenth and final round, participants were asked to estimate, in percentage terms, which probability the ball had to land in a slot of a *different* colour than in the previous round, and which probability it had to land on the *identical* colour. Then, they were asked to choose which colour they would bet on and, finally, how much they would bet.

Actually, the outcomes of the first 12 rounds were not random but predetermined in order to present, in each condition, a specific outcome sequence differing from the others in its final part. More specifically, in two conditions, the sequence ended with the last four throws having the same colour (four red or four black); instead, in the other two (i.e. control) conditions, only the last outcome had a different colour (red or black) from the previous one.

The hypotheses underpinning the study were the following:

If the manipulation were successful, then in the two conditions with long runs (4 last outcomes with red or black colour) one or the other fallacy should be induced. More specifically, since the presented sequences were composed of random events not associated with either wins or losses or with intentional actions, we expected the induction of the gambler's fallacy rather than the hot hand fallacy (Ayton & Fisher, 2004; Boynton, 2003; Caruso et al., 2010; Sundali & Croson, 2006). In the control conditions, no fallacy was expected: so, the participants' choices should be random.

In addition, if one or the other fallacy were based on the probability estimate about the future occurrence of the chosen event, there should be a causal relationship between the two variables: in the two fallacy-inducing conditions, the participants should choose the colour slot whose probability had been overestimated. Furthermore, if the bet amount were based on the probability estimates of winning, there should be a relationship between probability estimates, choice of slot colour on which to bet, and bet amount. A main effect was also expected between the two participants' groups: all conditions being equal, problem gamblers should incur more than non-problem gamblers in one of the fallacies, and should make more sizable bets.

Finally, it was expected that participants scoring higher on sensation seeking and impulsivity should made higher bets.

Two indices of fallacy, the probability estimate of each of the two outcomes (red or black slot) and the choice of the outcome on which to bet, were used in order to explicitly test whether the choice was based on erroneous evaluations of probability, i.e. on cognitive processes, or on the preference for a colour rather than another, i.e. on affective processes. Moreover, the probability estimates were requested before the choice of the outcome which to bet on in order to prevent the possibility that participants, after their choice, would misinterpret the questions on probabilities as questions about how much they thought they were lucky[37]. Finally, asking to estimate the percentage probability of both outcomes aimed to avoid that participants focused only on one outcome and to investigate whether they perceived the two probabilities as complementary or independent from each other. In the first case, their sum would be 1, in the second not.

Experiment

Participants

The participants were the same as the other two experiments. Their features and the recruitment procedure were already descripted in the previous study. They signed the informed consent form before the experiment.

Design

The 2 x 2 x 2 quasi-experimental design involved 3 between-subjects variables: *run length* (i.e. the number of times that the same colour appeared consecutively in the final part

[37] This possibility has been discussed in Matarazzo et al. (2017).

of the run: 4 times vs. 1 time), *colour* (i.e. one of the two slot colour on which the ball landed: red vs. black), and *gambling status* (problem gamblers vs. non-problem gamblers).

The dependent variables were the *probability estimates* that in the next round the ball would land on the red slot*; the probability estimates* that it would land on the black slot*;* the *choice* of the colour slot on which to bet, and the *bet* amount.

Materials and procedure

The instructions informed that the present study entailed the participation in a roulette game with only two colours: red and black. They explained that participants would attend a series of 12 roulette rounds, for each of which they would see the outcome (i.e. whether the ball would land on red or on black slot). At the thirteen round, they would be asked to choose the slot colour on which they would bet, and to indicate the bet amount. They were also informed that at the thirteen round, a 20 chips budget would be available.

Once they read the instructions, the participants could press the "Next" button to begin the experiment.

Each of the first 12 rounds was composed of two phases. In the first one, a screen was presented showing a Graphics Interchange Format image of a roulette wheel rotating with a white ball on the inside ball track. By pressing the "Next" button, the participant went to the second phase in which a second screen appeared showing an image of the outcome accompanied by the phrase "The ball landed on a red (or black) slot". Both phases had no time limit. The "Next" button allowed them to switch to the next round.

At the thirteenth and final round, participants were asked to indicate, on a scale from 1 to 100, the probability that in the next round the ball would land on a colour *different* from that of the last round, and the probability that it would land on the *same* colour as last round. The order of the two questions was counterbalanced across participants. For example, in the two conditions in which the sequences ended with the ball in a red slot, the questions were the following: "*How much do you think it is likely that the ball will land on a black slot?*

Indicate the probability, in percentage, by typing on the keyboard a number from 1 to 100". *"How much do you think it is likely that the ball will lands on a red slot? Indicate the probability, in percentage, by typing on the keyboard a number from 1 to 100"*.

Then, they were asked to choose the slot colour which to bet on ("*Select Red or Black to indicate which colour you want bet on"*). The two options were presented in a counterbalanced order. Finally, they had to indicate, on a scale from 1 to 10, how many chips they wanted to bet on their choice ("*Your available budget is 20 chips. How much would you bet from 1 to 10*?").

As mentioned earlier, the outcomes of the first 12 rounds were not casual but predetermined in such a way to create the 4 experimental conditions - *2 fallacy-inducing conditions* and *2 control conditions* - by varying run length (4 vs. 1) and series colour (red vs. black). In the two *fallacy-inducing conditions*, the outcome sequences were constructed so that in the last 4 rounds the ball always landed on red slots (*four-red* condition) or on black slots (*four-black* condition). These two different sequences were created in order to control a possible colour preference and to disentangle this phenomenon from one or the other fallacy. In the two *control conditions* (*one-red* condition *vs. one-black* condition), the outcomes sequences were constructed in such a way to seem representative of a casually generated sequence. At this end, it was avoided that in the first 12 rounds the ball landed more than two consecutive times in a slot of the same colour. Moreover, the colour of the twelfth round always differed from that of the eleventh round.

The task was implemented using Survey Monkey software. Also in this experiment, the choice of this software was based on the possibility to support a Graphics Interchange Format image of a roulette wheel rotating with a ball on the inside ball track. As mentioned before, the experiment was not carry out online but rather in appropriate rooms provided by the Gambling addiction Services for all participants (problem gamblers and non-problem gamblers).

The participants took about 15 minutes to complete the experiment, after which they were thanked.

As it was written in describing the study of the illusion of control, at the end of the three experiments, participants completed, in a counterbalanced order, BIS-11 and BSSS. Finally, they completed the SOGS. As I already wrote, at the end of the three experiments participants were carefully debriefed. During the debriefing, they were clarified about the research hypotheses and it was ensured that they had not suspected the study purposes during the experimental session.

Results

Preliminarily, the effects of the independent variables – *run length* (4 vs. 1), *colour* (black vs. red), and *gambling status* (problem gamblers vs. non-problem gamblers) - on each of the three dependent variables (*probability estimates* of each of the two next slot colours, *choice* of the colour on which to bet, and *bet amount*) were tested.

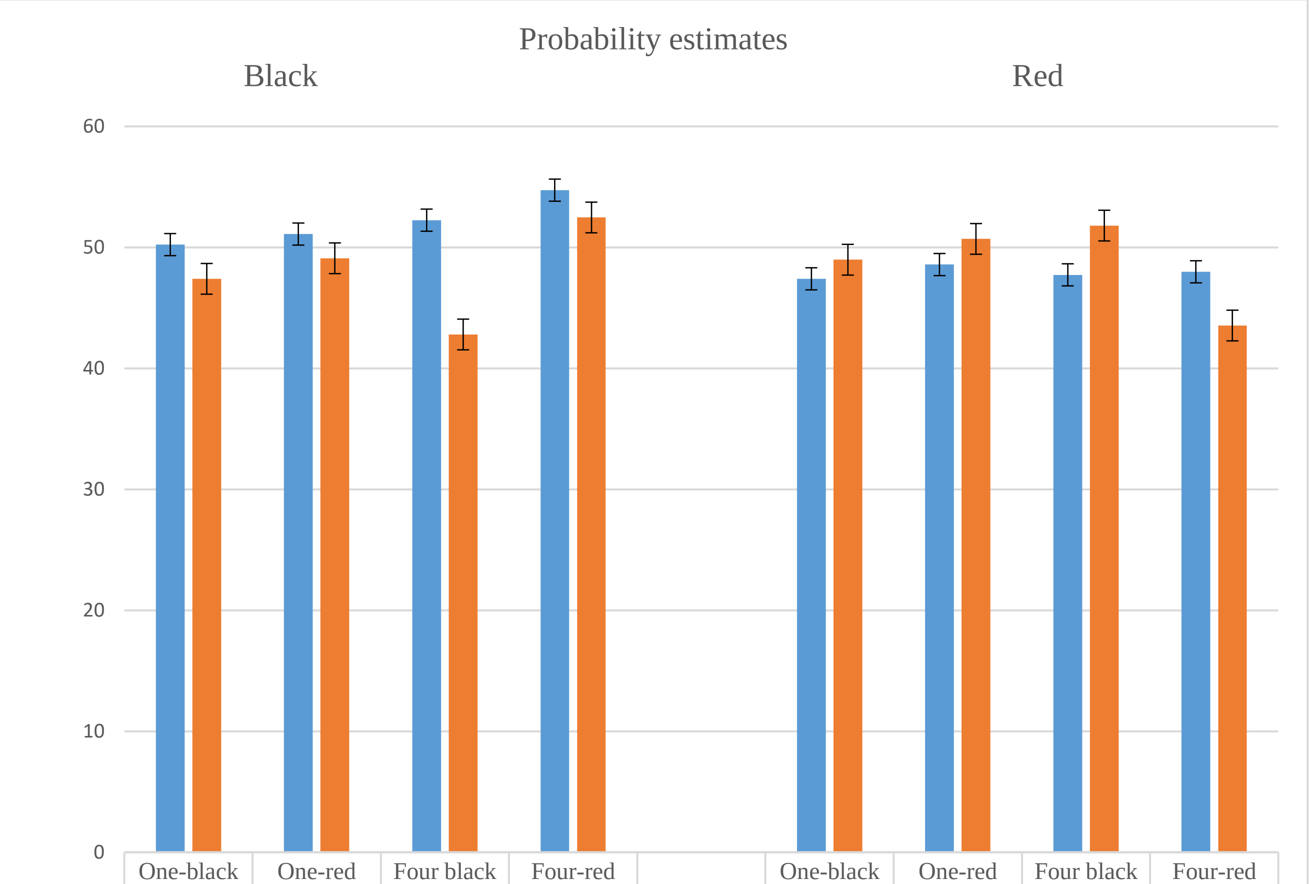
Analogously to the study on the illusion of control, the data were first analysed without the two covariates, i.e. the BSSS and BIS_11 scores, and then with the two covariates in order to examine their impact on the results.

Probability

In order to examine the incidence of the three independent variables on participants' probability estimates, a 2 (*run length*: 4 vs. 1) x 2 (*colour*: red vs. black) x 2 (*gambling status*: problem gamblers vs. non-problem gamblers) x 2 (*probability*: red and black) mixed ANOVA was performed. The between-subjects variables were *run length*, *colour* and *gambling status*. The within variable was the *probability estimates* (2 levels: *red vs. black)*.

Graphic 1 shows the participants' probability estimates in the study conditions.

Graphic n.1: Means (with SD in bars) of participants' probability estimates as a function of the study conditions (PG= problem gamblers; NPG=non-problem gamblers).



	One-black	One-red	Four black	Four-red		One-black	One-red	Four black	Four-red
NPG	50,23	51,1	52,25	54,73		47,4	48,58	47,73	47,98
PG	47,4	49,1	42,8	52,47		48,98	50,7	51,8	43,54

The results revealed a main effect of *Gambling status* $F_{1,312} = 5.289$; $p < .05$; $p\eta^2 = .017$: non-problem gamblers provided higher probability estimates (49,9%) than problem gamblers (48.3%). They also revealed two two-way interactions, *gambling status x probability*, $F_{1,312} = 6.041$; $p< .05$; $p\eta^2 = .019$, *colour x probability*, $F_{1,312} =6.041$; $p< .05$; $p\eta^2 = .019$, and two three-way interactions, *run length x colour* x *probability*, $F_{1,312} = 6.071$; $p< .05$; $p\eta^2 = .019$, *gambling status x colour x probability*, $F_{1,312} = 3.953$; $p< .05$; $p\eta^2 = .013$. The interactions were examined through simple effects analysis with Bonferroni adjustment for multiple comparisons.

The *gambling status x probability* interaction was due to the fact that non-problem gamblers estimated the black probability (52.07%) to be higher than the red probability (47.91%), whereas problem gamblers estimated analogously the two probabilities (47.86% vs. 48.75%, respectively).

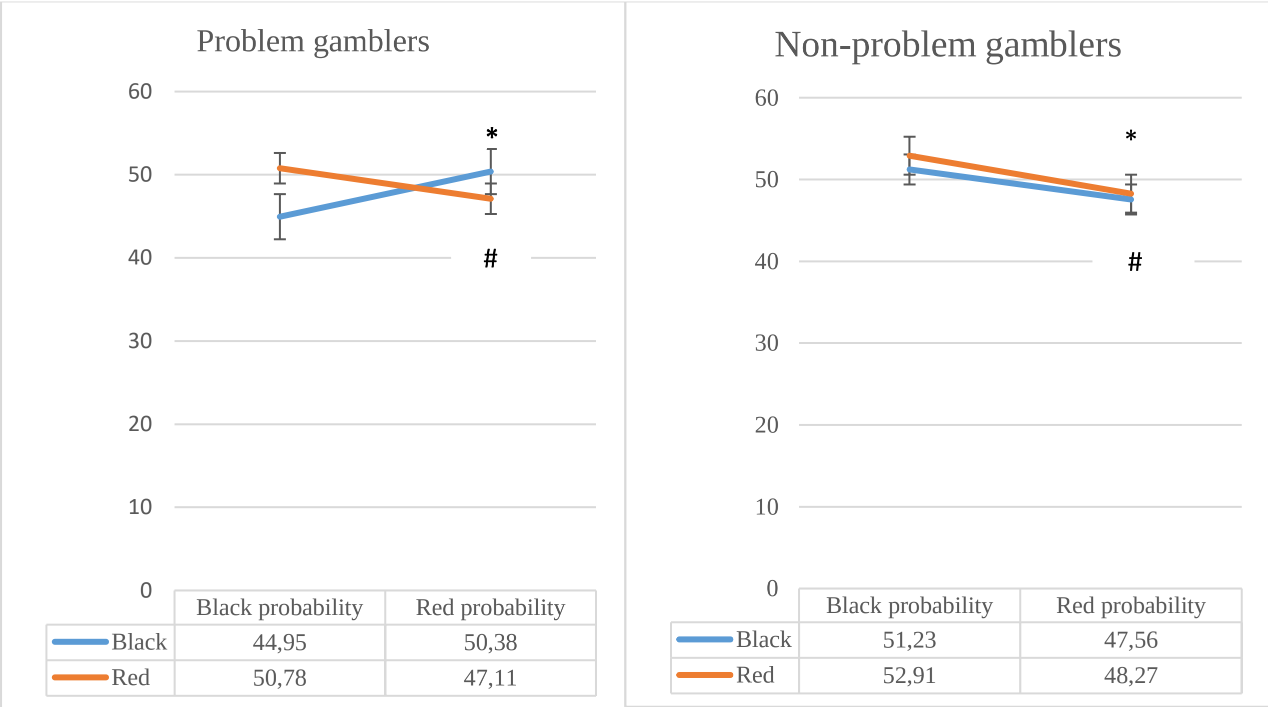
The *colour x probability* interaction was due to the fact in the conditions in which the sequence ended with (four or one) red slot(s), participants estimated the black probability (51.85%) to be higher than red probability (47.69%), whereas no difference appeared when the final colour(s) of the sequence was/were black (48.09% for black probability vs. 48.97 for red probability).

The three-way interaction *gambling status x colour x probability*, in which the two-way interactions were comprised, showed that *problem gamblers*, in the two conditions where sequences ended with (four or one) *black* slot(s), estimated the *red probability* (50.38%) to be higher than the *black probability* (44.95%), whereas no significant effect appeared when sequences ended with red colour (red probability = 47.11%; black probability = 50.78%). Conversely, *non-problem gamblers*, in the two conditions where sequences ended with (four or one) *red* slot(s), estimated the black probability (52.91%) to be higher than the *red probability* (48.27%), whereas no significant effect appeared when sequences ended with black colour (red probability = 47.56%; black probability = 51.23%).

The *run length x colour* x *probability* interaction revealed that in the condition in which the sequence ended with four red slots, the black probability (53.6%) was higher than the red probability (45.75%), whereas no significant difference was found in the other conditions (the percentage values are reported in the graphic n.3).

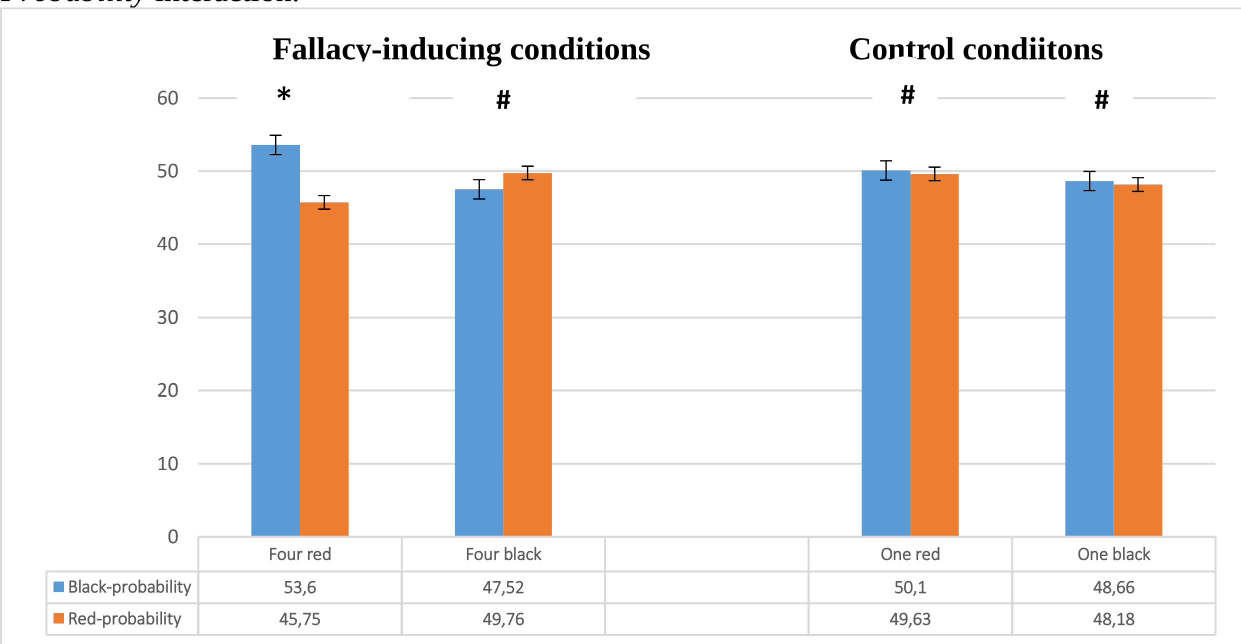
The graphic n. 2 and 3 show the *gambling status x colour x probability* and the *run length x colour* x *probability* interactions, respectively.

Graphic 2: Means of probability estimates (with SD in bars) in the three-way *Gambling status x Colour x Probability x* interaction.



*p <.05; #ns

Graphic 3: Means (with SD in bars) of probability estimates in the three-way *Run length x Colour x Probability* interaction.



Fallacy-inducing conditions: conditions ending with four black/red slots. Control conditions: conditions ending with one black/red slot.

*p<.000; #ns.

The ANCOVA[38] model testing the effect of the two covariates on participants' probability estimates showed that the main effect of the *gambling status* was no longer significant, $F_{1,310} = 1.945$; $p = .164$. However, the value of the interaction *gambling status* x *probability* increased, $F_{1,310} = 9.819$; $p < .01$; $p\eta^2 = .031$. All other results remained similar to those of the ANOVA. Nevertheless, the three-way interaction *gambling status x colour x probability* was slightly changed compared to the ANOVA: problem *gamblers*, in the two conditions where sequences ended with (four or one) *black* slot(s), estimated the red probability (51.41%) to be higher than the *black probability* (44.59%), whereas no significant effect appeared when sequences ended with red colour (red probability = 47.76%; black probability = 50.49). Instead, *non-problem gamblers*, regardless of the experimental conditions, estimated the black *probability* to be higher than the red probability (53.23% vs. 47.52% when the sequence ended with red, 51.71% vs. 46.65% when the sequence ended with black colour).

To investigate whether the participants perceived *red probability* and *black probability* as complementary or independent from each other as a function of experimental conditions and gambling *status*, three chi-squares were performed on the following variables, calculated *ad hoc*: a) the number of cases where the sum of the two probabilities in percentage was equal to 100 (i.e. for which the two probabilities were complementary); b) the number of cases where each of the two probabilities was equal to 50 (i.e. those giving correct probabilities); c) the number of cases where the sum of the two probabilities was different from 100 (i.e. for which the two probabilities were independent from each other)[39]. None of the results was statistically significant: neither the experimental condition nor the gambling *status* affected participants' conceptions of probability[40].

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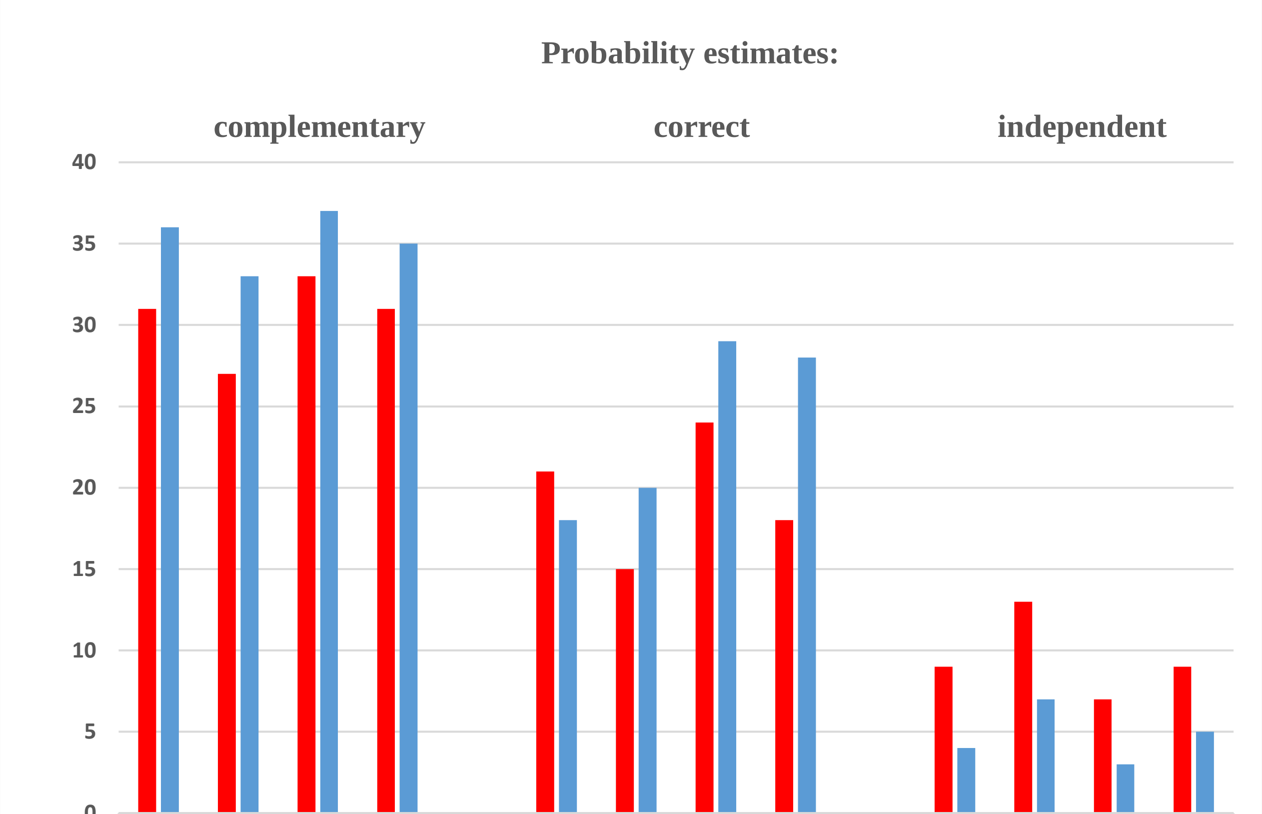
[38] The ANCOVA was performed after checking that the assumption of homogeneity of regression slopes had been respected: indeed there were no interactions between the independent variables and the covariates.

[39] Note that the cases in the group b) were a sub-category of those in the group a) and that the sum of the cases in groups a) and c) was equal to the totality of participants.

[40] Complementary probability estimates: $\chi 2$ (3) = .072, p = .995. Correct probability estimates: $\chi 2$ (3) = .1.939, p = .585. Independent probability estimates: $\chi 2$ (3) = .149, p = .985.

In graphic 4 the distribution of the three types of probability conceptions in function of the independent variables were reported.

Graphic 4. Distribution of the three types of probability conceptions in function of the independent variables



	4 Red	4 Black	1 Red	1 Black		4 Red	4 Black	1 Red	1 Black		4 Red	4 Black	1 Red	1 Black
PG	31	27	33	31		21	15	24	18		9	13	7	9
NPG	36	33	37	35		18	20	29	28		4	7	3	5

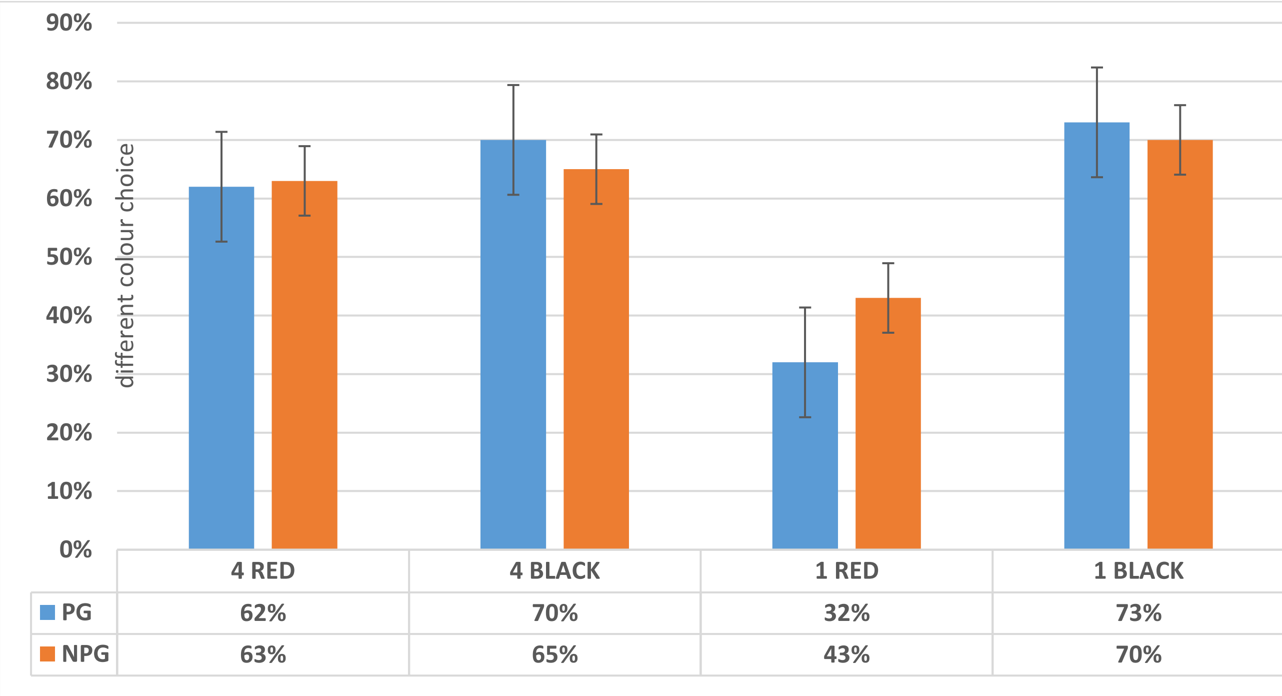
PG= problem gamblers; NPG=non-problem gamblers; 4Red/4 Black/1Red/1Black = experimental conditions

Choice

In order to assess the incidence of the three independent variables on the choice of the colour which bet on, a 2 (*run length*: 4 vs. 1) x 2 (*colour*: red vs. black) x 2 (*gambling status*: problem gamblers vs. non-problem gamblers) between-subjects ANOVA was performed. Choice was coded as a dummy variable (1 = choice of a colour different from the last one occurring in the sequence; 0 = choice of the same colour as the last one in the sequence); so, ANOVA was performed on the proportion of the different colour choices.

Graphic 4 shows the distribution of the different colour choices made by the two participants groups' in the 13th round.

Graphic 4. Percentage (with SD in bars) of the different colour choices as a function of the study conditions

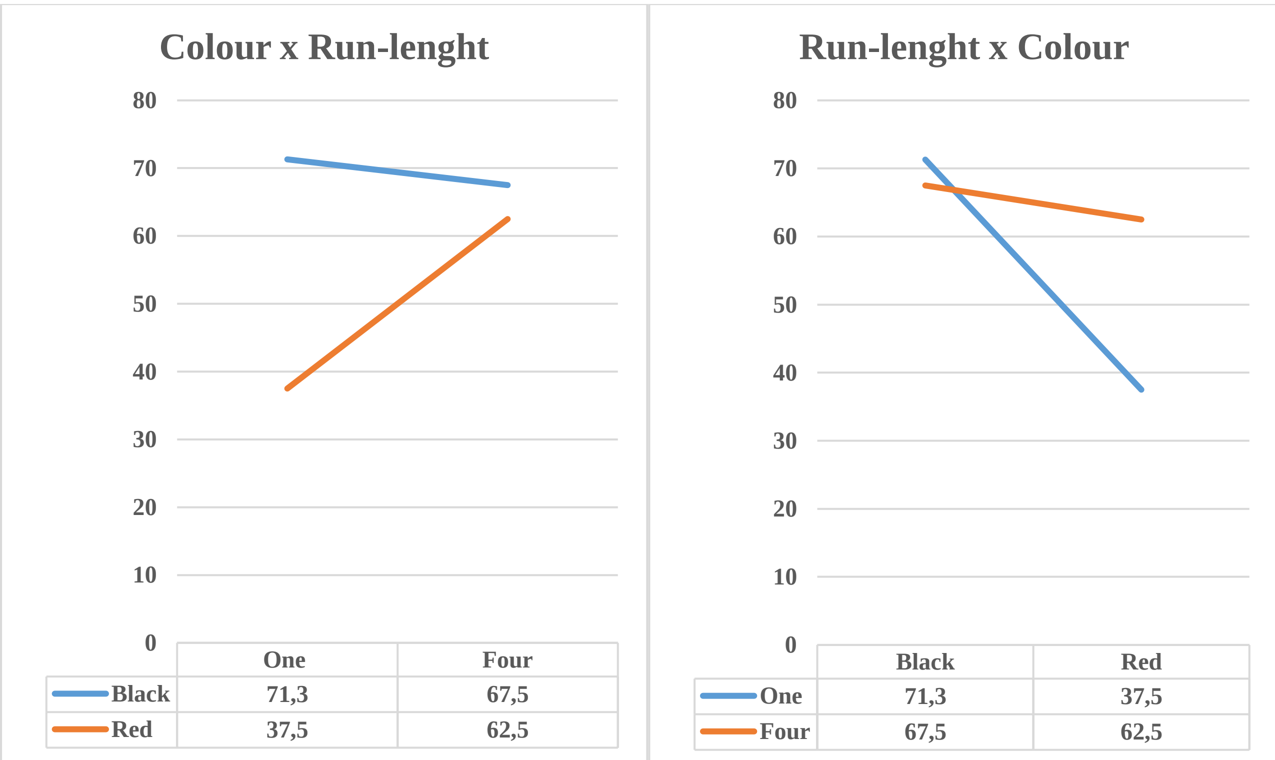


PG= problem gamblers; NPG= non-problem gamblers; 4Red/4 Black/1Red/1Black = experimental conditions

Results revealed two main effects: *colour*, $F_{1, 312} = 13.164$; $p < .001$; $p\eta^2 = .04$, and *run length*, $F_{1, 312} = 3.959$; $p < .05$; $p\eta^2 = .013$. Pairwise comparisons with Bonferroni adjustment showed that the percentage of the *different* colour choice was higher in the conditions where sequences ended with the ball landing on a *black* slot (69.4%) than in those where sequences ended with a *red* one (50%). Moreover, this type of choice was higher with the series of four same colours (65%) than with that of one colour (54.4%).

Results also revealed a two-way *colour* x *run length* interaction, $F_{1,312} = 7.247$; $p < .05$; $p\eta^2 = .023$, which was examined by means of simple effects analysis followed by pairwise comparisons with Bonferroni adjustment for multiple comparisons. Results (reported in graphic 5) showed that, in line with the gambler's fallacy, in the *four-red condition*, the percentage of the different colour choice was higher (62.5%) than in *the one-red* (control) condition (37.5%). On the contrary, the different colour choices did not differ between the *four-black* condition (67.5%) and the *one-black* condition (71.3%), as both groups preferred to bet on a red slot. In fact, by analysing this interaction from the perspective of the run length, it emerged that in the *one-black* condition the percentage of the different (i.e. red) colour choice was higher (71.3%) than in the *one-red* condition, where that of the different (black) colour was 37.5%. Instead, the different colour choice did not differ between the *four-black* (67.5%) and f*our-red* conditions (62.5%). *Gambling status* did not affect the participants' choices.

Graphic n.5: Percentage of the different colour choices as a function of *run length* and *run colour*. The left side shows the significant difference between the means of the different choices in the two conditions in which the sequences ended with a red outcome. The right side shows the significant difference between the means of the different choices in the two control conditions (71.3% vs 37.5%).



These results suggest that participants preferred to bet on a red slot but, when this preference was in contrast with the gambler's fallacy (i.e. with four red runs), their choice was no longer in line with the basic preference but was inverted, becoming in line with the gambler's fallacy. The same results were obtained from ANCOVA.

Bet amount

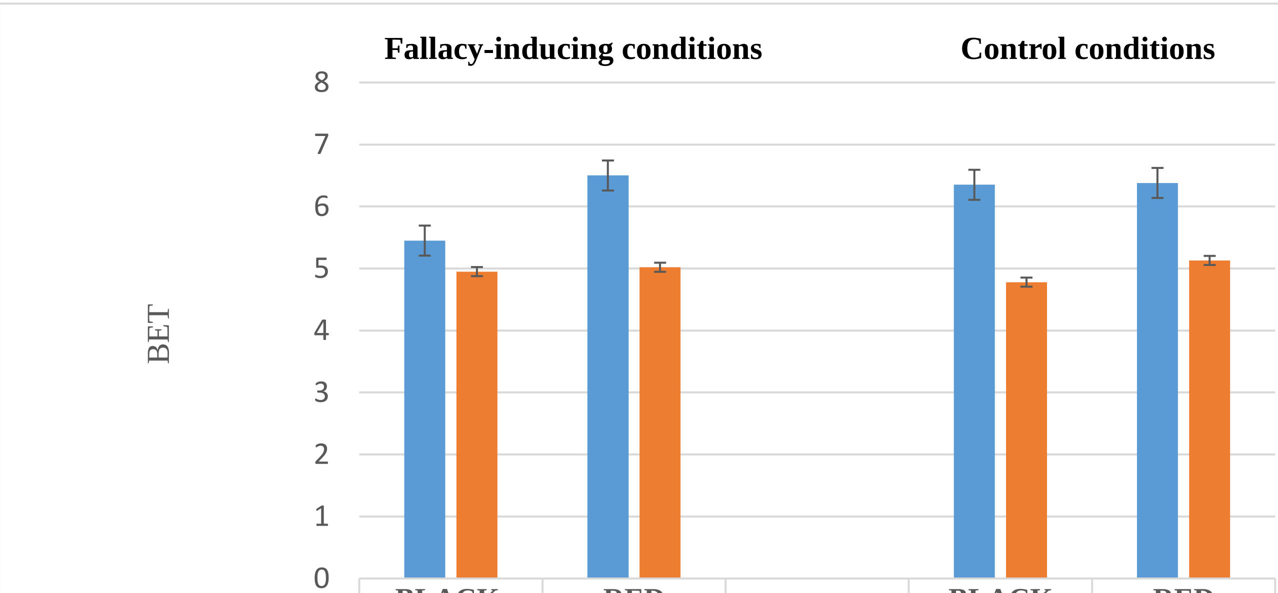
In order to assess the incidence of the three independent variables on the bets carried out by participants, a 2 (*run length*: 4 vs. 1) x 2 (*colour*: red vs. black) x 2 (*gambling status*: problem gamblers vs non-problem gamblers) between-subjects ANOVA was performed. The dependent variable was the *bet amount*.

Graphic 6 shows the participants' bets in the study conditions.

Results revealed only a main effect of the *gambling status*, $F_{1.312} = 26.811$; $p < .000$; $p\eta^2 = .079$. Pairwise comparisons showed that the bet amount was higher in problem gamblers (6.16) than in non-problem gamblers (4.96). *Run length* and *colour* did not affect the participants' bets.

The same results were obtained from ANCOVA.

Graphic 6. Mean (with SD in bars) of participants' bets as a function of the study conditions.



	BLACK	RED		BLACK	RED
Problem gamblers	5,45	6,5		6,35	6,38
Non-problem gamblers	4,95	5,02		4,78	5,13

Once again, when BSSS and BIS scores were entered into the model as covariates, results did not show different effects.

Moderated mediation analyses

To investigate whether the effect of *run length* on *choice* was moderated by *colour* and *gambling status* and mediated by *probability estimates*, a moderated mediation analysis using the PROCESS macro (model 10) for SPSS (Hayes, 2013) was carried out. To this end, the run length, coded as dummy variable (1 = 4 vs. 0 = 1), was introduced in the model as independent variable. *Colour* (1 = red; 0 = black) and *gambling status* (1 = problem gamblers; 0 = non-problem gamblers) were introduced as moderators. As the probability estimates were repeated measures, *probability delta* was calculated, by subtracting red probability value from that of black probability, and introduced as mediator (Montoya & Hayes, 2017). *Choice*, coded as a dummy variable (1 = choice of a colour different from the last one occurring in the sequence; 0= same colour) was the criterion variable.

Results revealed that *run length x colour* interaction affected *probability delta*: compared to other conditions, *four-red ending condition* produced an increase in probability delta (B= 10.1; SE = 4.134; t = 2.4432; $p < .05$).

When previous variables and the putative mediator, *probability delta*, were entered in the equation regression to estimate the moderated mediation effect on *choice*, results revealed that choice was affected by *colour* (B= -1.421; SE = .3386; z = -4.1969; $p < .000$) and by the *run length x colour* interaction (B= 1.2169; SE = .479; z = 2.5405; $p < .05$). Compared to ending-black series, ending-red series produced a decrease of different colour choices; compared to the other conditions, the ending-four-red series produced an increase in different colour choice. Probability delta did not affect choice (B = -.0016; SE = .0064; z = -.2503; p = .8024).

The conditional direct effect of the run length on choice was moderated by colour both in problem gamblers and in non-problem gamblers. Compared to the one run length (assumed as reference category), when the four run length ended with the red colour, produced in both problem gamblers (B = 1.1748; SE = .4086, z = 2.8749; $p < .005$; 95% CI = .3739, 1.9757) and non-problem gamblers (B = .8952; SE = .4047, z = 2.2123; $p < .05$; 95% CI = .1021, 1.6883) an increase of different colour choices.

Results showed no conditional indirect effects[41] of run length on choice through probability delta (i.e. no moderated mediation was found). Compared to the control condition, the effect of 4 run length on choice was not mediate by probability delta, independently by the value assumed by colour and group.

The moderated mediation analyses in which the BSSS and BIS-11 scores were entered into the model showed that *gambling status* affected probability delta. Compared to non-problem gamblers, probability delta decreased in problem gamblers (B= -6.4404; SE = 3.1027; t = -2.0757; p < .05): in line with the ANOVA' results, black and red probability estimates were more similar in problem gamblers than in non-problem gamblers.

To investigate whether the effect of *run length* on the *bet amount* was moderated by *colour* and *gambling status* and mediated by *probability estimates* and *choice*, two different analyses were carried out. As neither Process macro nor Mplus structural equation models allow a dichotomous mediator (i.e. choice), the following analyses were performed: a first moderated mediation analysis on bet amount similar to the one above described and a multiple regression analysis, in which choice was included among predictors.

Concerning the results of the moderated mediation analysis, the effects of the independent variable and moderators on probability delta were already described. When all predictors were entered in the equation regression to estimate the moderated mediation effect on the bet amount, results showed only the effect of *gambling status* (B= 1.4353; SE = .3294; t = 4.358; p < .000): compared to non-problem gamblers, problem gamblers bet more. No conditional direct or indirect effects of the run length on bet amount were found.

Then, a multiple linear regression was performed entering *run length*, *colour*, *gambling status*, *delta probability* and *choice*, as predictors of the *bet amount*. Entering *choice* into the regression equation did not change previous results: only *gambling status* (B = .794; SE = .269; t = 2.953; p < .005) affected bet amount: problem gamblers bet more than non-problem gamblers.

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[41] The indirect effects were estimated using 5000 bootstrap samples with 95% bias corrected confidence intervals.

The analyses conducted by introducing also the BSSS and BIS-11 scores as covariates in the model showed the same effects above reported.

Discussion and conclusions

The study has investigated the occurrence of the gambler's fallacy (or the hot hand fallacy) and its relationship with probability estimates of the next outcome and the bet amount in a fictitious roulette game. More precisely, it was investigated whether a series of identical outcomes in a roulette wheel induced one of the two fallacies and whether the induced fallacy was linked to an increase in probability estimates of the target event and in the bet size. The study also investigated whether such effects were present to a different extent in problem gamblers and non-problem gamblers. Finally, the study aimed to distinguish the role played by cognitive (i.e. erroneous probability estimates) and affective (i.e. the preference for a colour rather than another) processes in the choice of the colour on which to bet. To this end, two different indices of fallacy were used: a cognitive index, the probability estimate of each of two possible roulette outcomes[42], and a behavioural index, the choice of the outcome on which to bet. As it was written in the overview of the study, the request of estimating the probability (in percentage) of the two outcomes aimed to investigate whether participants perceived the two probabilities as complementary or independent from each other.

Overall, the results highlighted that, regardless of their gambling status, the participants' choices were mainly based on a preference for the red slot. Such a preference was reversed in a choice in line with the gambler's fallacy (i.e. choosing a black slot) only when the sequence ended with four red slots. More precisely, in the conditions where the sequences ended with black slots, the participants preferred to bet on a red slot, independently from the run length. On the contrary, in the conditions where the sequences ended with red slots, the gambler's fallacy was manifest: in such conditions, choosing black increased after a

[42] The roulette used for the study was modified ad hoc and entailed only two outcomes: red and black.

sequence of four red slots compared to that of one red slot. The probability estimate did not affect the choice[43].

Such results seem to indicate that the people's choices were based on affective processes, the preference for a colour (red rather than black), rather than on erroneous evaluations of probability, index of a cognitive process. This result is in line with the study of Matarazzo et al. (2017) where, in a card guessing game (high vs. low card), the participants preferred to bet mainly on high cards and reversed this tendency, choosing low cards (according with the gambler's fallacy), only when the run of high-cards increased (4 high cards vs. 1 high card). On the contrary, when the sequences ended with low cards, participants preferred to bet on high cards, independently of the series length.

The influence of the slot colour on participants' judgment was found even in the results concerning the probability estimates of the next outcome, emerging both from ANOVA and from the mediation analysis. In the condition in which the sequence ended with four red slots, the black probability was higher than the red probability, whereas no difference due to the colour emerged in the other conditions. Therefore these results, showing that a stimulus feature, such as colour, has moderated a cognitive process, as probability estimates, highlight the role played by intrinsic, contextual or spurious factors in phenomena as the cognitive distortions. To the best of my knowledge, the incidence of simple stimulus features on the occurrence of the gambler's fallacy has been found only in Matarazzo et al.'s study (2017).

From the review of the literature on the gambler's and hot hand fallacies, it emerges that the factors assumed to affect one or the other phenomenon have been the representativeness heuristic (Tversky & Kahneman, 1971; Kahneman, & Tversky, 1972; Rabin, 2002), the level of controllability of the events (Ayton & Fisher, 2004, Burns & Corpus, 2004), the prior successes or failures (Boynton, 2003), the different cognitive load required by the gambler's fallacy vs. the hot hand fallacy (Braga et al., 2013), the degree of perceived intentionality exerted by the agent generating the runs (Caruso et al. 2010), and so on. It should be noted that, in the present study, the use of two distinct (cognitive and behavioural) indexes of fallacy has allowed inferring that choice and probability estimates seem to be two independent processes.

[43] As it has been written in the results section, in the moderated mediation analysis the difference between black and red probability values was entered in the model as putative mediator.

Concerning the third index of fallacy, i.e. the bet amount, the results showed only the effect due to the gambling status: problem gamblers bet more than non-problem gamblers. Probability estimates choice and covariates did not affect the bet amount.

In the present study, two differences due to the gambling status were found: problem gamblers bet more than non-problem gamblers, and the distance between black and red probability estimates was reduced in problem gamblers compared to non-problem gamblers. However, as probability estimates did not affect the bet amount, one cannot infer that problem gamblers bet more than non-problem gamblers despite of their less proneness to probability distortions. Since the participants were the same as in the previous study, it must be remembered that problem gamblers scored higher than non-problem gamblers on the sensation-seeking and impulsivity scales. Nevertheless, also in this study no covariates effect on any of the fallacy-indexes was found. So, once again one must acknowledge that these results do not corroborate the widespread hypotheses that higher proneness to cognitive distortions, such as the gambler's fallacy, and specific personality factors, such higher levels of impulsivity and sensation-seeking, make people more subject to the illusion of control and to related behaviors, such as the increase in bet amount (Davis et al., 2000; Griffiths, 1994; Lim et al. 2015; Ladouceur & Walker, 1996; Michalczuk et al. 2011; Miller & Currie, 2008; Myrseth et al. 2010; Nower et al., 2004; Petry, 2001; Romo et al., 2016).

Finally, it is noteworthy that in this study the probabilities attributed to black and red outcomes were more correctly estimated than in the previous study on the illusion of control (with the same participants): regardless of experimental conditions and gambling status, 263 participants out of 320 considered the two probabilities complementary (and 173 evaluated them correctly), while the remaining 57 considered the two probabilities as reciprocally independent.

Perhaps this difference is due to the fact that in the previous study it was asked to estimate the winning probabilities linked to each agent choice, whereas in this study the questions concerned merely the probability of occurrence of each of the two possible outcomes.

CHAPTER IV

Emotions and decision-making in problem gamblers and non-problem gamblers

Psychological research has widely acknowledged the role that emotions exert on cognitive processes, as well as on decision-making. Scholars suggested that emotions affect decisions in different ways. Loewenstein & Lerner (2003) proposed a distinction between *anticipated* and *immediate* emotions. Anticipated, or expected, emotions involve expectations on the emotional consequences that will be experienced when the outcome of choices materializes. They are not felt as emotions at the time of the decision but are predictions about the emotional outcomes associated with the various alternative courses of an action. So, they are characterized by a strong cognitive component. Such emotional states are related to the individual's experiential baggage and are used to evaluate future events similar to those experienced in the past. Based on the emotional valence re-activated by the emotion previously felt, the decision-maker will choose the most appropriate behaviour to adopt (Blanchette & Richards, 2010). Differently, immediate emotions are experienced at the time of decision and are due to the presence of the stimulus. They are distinguished by a somatic component, such as facial expressions and changes in the autonomic nervous system. Immediate emotions have been distinguished in *integral* emotions, which arise from the object of decision and its affective valence, and *incidental* emotions, which arise from factors disconnected from the decision-making context (Bodenhausen, 1993; Loewenstein & Lerner, 2003). These factors are independent from the decisional stimulus and may include the immediate environment or chronic dispositional affects. Their influences are difficult to predict as incidental emotions, by definition, arise from factors that are irrelevant to the decision (Pham, 2007).

4.1. Incidental emotions and risk-taking in decision-making

The research of the influences of the incidental emotions on decision-making has adopted two main approaches: one based on *valence* and the other based on *cognitive appraisal*. *The valence*-based perspective considers the hedonic qualities of emotion, mood or affect, as these terms are used often in an interchangeable way. Different emotions of the same valence would exert similar influences on decision-making. Regarding risk-proneness, two leading valence-based hypotheses have been advanced: *Mood Maintenance Hypothesis* (MMH, Isen, 1978), and the *Affect Infusion Model* (AIM, Forgas, 1995). According to MMH, the effect of emotional states on the tendency to take risks is explained by an innate desire to *maintain* a positive affective state or to mitigate a negative one. Specifically, individuals in a positive emotional state tend to behave cautiously in order to preserve their positive affective status, thus avoiding risks. On the contrary, individuals in a negative emotional state tend to be more willing to accept risks in order to improve their emotional state (Isen & Patrick, 1983). As regards negative emotional states, empirical support for this hypothesis derives from the studies of Gehring & Willoughby (2002), showing that risky choices increased after negative experiences as a strategy for improving their current emotional state, and Chuang & Kung (2005), where participants in a negative emotional state preferred more risky choices than those in a positive one. Analogously, Kliger & Levy's study (2003) showed that the positive emotional state was associated with risk aversion. Instead, according to the AIM, emotions can influence the evaluation of judgments and decision-making through a "congruence effect". Thus, the valence of the evaluation would be in line with the actual emotional state. This model hypothesizes that a positive emotional state leads to a more positive evaluation of owns thoughts and environmental objects, which in turn increases the tendency to take risks; conversely, a negative emotional state, influencing evaluations and judgments in a similar way, can lead to risk-avoiding behaviours. Empirical support for these hypotheses derives from Constants & Mathews's study (1993), where participants induced in a positive emotional state by autobiographical recall technique, estimated more likely the occurrence of positive future events than those induced in a negative emotional state. In Yuen & Lee's study (2003), the induction of a negative emotional state by movie clips caused in participants a lower disposition to take risks, operationalized as hypothetical choices in everyday life dilemmas, compared to those induced in a positive or neutral emotional state. An analogous trend was found by the study of Chou et al. (2007), where the risk was defined by the same procedure used by Yuen & Lee. Induced participants in a positive emotional state by movie clip increased their willingness to take risks compared to those in a negative emotional state. In the study of Xie et al. (2011), the induction by picture of a positive emotional state increased optimism levels and reduced risk perception.

However, some studies found mixed results in line with both the predictions of the two theories. Williams et al. (2003) showed that participants in a positive emotional state were less willing to take risks and, at the same time, those in a negative emotional state did not show risk-proneness. Similarly, Drichoutis & Nayga (2013) showed that both negative and positive emotional states increased the tendency to avoid risks.

A limit of the value-based approach is the inability to identify whether different emotions of the same valence would affect decisions in a different way. Instead, the *Appraisal Tendency Framework* (ATF), proposed by Lerner & Keltner (2000, 2001), assumes that *specific emotions have specific effects on decision-making* and that such effects would result from the *different evaluation schemes* of every emotion. According to this perspective, emotional states evoke specific cognitive styles and assessments that integrate information and prioritize different outcomes. Based on the appraisal theories (Smith & Ellsworth, 1985, Lazarus, 1991), according to which each emotion would be characterized by a single evaluation scheme laid on central dimensions (i.e.: pleasure, certainty, control), the ATF assumes that each emotion activates a cognitive predisposition to evaluate future events in line with the central evaluation dimension triggering the emotion. This predisposition for future evaluation is the tendency towards the evaluation, which is the basis of the effects through which emotions influence judgments and decision-making.

According to ATF, the dimensions of *certainty* and *control* appear to be particularly influential in the context of decision-making because of their close association with cognitive assessments determining risk estimates. For example, *fear* is typically evoked in situations where the outcome is uncertain. Such uncertainty characterizes the evaluation scheme that influences the judgment and, in turn, increases the risk estimates. Differently, *anger* is evoked in situations of *low uncertainty*: being characterized by high evaluations of both certainty and control, it would reduce risk estimates.

Several studies have provided empirical support to this theory, showing that emotions with the same valence can have divergent effects on decision-making. Raghunathan & Pham (1999) found that low-activation threshold emotions, such as *sadness*, induced greater propensity towards high-risk and high-reward bets, while high-activation threshold emotions, such as anxiety, induced a preference towards low-risk and low-reward bets. Lerner & Keltner (2000) revealed that individuals in an emotional state of *fear* made cautious choices whereas those induced in a state of *anger* made more risky choices. In addition, the choices of the latter were similar to those of participants in a state of happiness. The study conducted by Fessler et al. (2004) also revealed that, using the autobiographical recall technique, high-activation negative emotional states, such as *anger,* increased risky choices. Moreover, the study conducted by Stanton et al. (2014) found that people induced in a positive emotional state via films tended to make more risky choices than those in a negative and neutral one, which did not show any differences.

4.2. Incidental emotions and risk-taking in problem-gamblers

A growing body of research indicates that, in problem gamblers, emotional states and cognitive distortions correlate with perseverance in gambling despite continuous losses. The studies focused on the relationship between gambling and states as social isolation, depression, anxiety, and stress, revealed that gamblers tend to increase such behaviour in order to alleviate their own negative emotional states. However, this behaviour seems efficacious to reduce such negative states in the short term but, in the long term, a rebound effect tends to worsen them (Dickerson, 1993; Coventry & Constable, 1999; Washburn et al., 2003; Williams et al., 2012).

Few studies investigated the effects of incidental emotions on decision-making in the gambling context. Potenza et al. (2003) compared the specific effects of *sadness* and *happiness*. Participants (10 pathological gamblers vs. 11 control subjects) were exposed to the viewing of 3 video-recorded scenarios, each of which entailed sad, happy or gambling content: their task was to indicate, by pressing a button, the emergence of an emotional or motivational response (need to drink, eat or gamble) while they watched the scenarios. At the end of the scenarios, participants had to indicate the intensity of their emotions and motivations. Results showed that the responses to the *sad* and *happy* scenarios did not differ between pathological gamblers and control participants. However, the responses to the gambling scenario differed, as shown by the greater intensity of the gamblers' need to play. In addition, gamblers did not need to play during the viewing of the sad and happy scenario, while this desire was felt viewing the gambling scenario. Instead, only 3 control group participants reported the need to play during the game scenario[44].

Hills et al. (2001) investigated the effect of emotional states on the number of rounds played in a computerized version of the *card-cutting game* (Breen and Zuckerman, 1999). The experimental procedure provided the assignment to three conditions, based on the induced emotional state (*sadness*, *happiness*, neutral), of 120 students rated as regular gamblers (those who bet at least once a week) and non-regular gamblers (those who bet less than once a month). A 10-minute video viewing induced the emotional state. The emotional measurements were recorded in three moments: after watching the video, after the first five-game rounds and at the end the game. The task of the participants was to bet on low or high cards. The results showed that in regular gamblers, the emotional induction did not affect the number of game rounds, which did not differ among the three experimental conditions. Among non-regular gamblers, those induced in a happy emotional state played more than those induced in a sad state did. In addition, no differences between regular and non-regular gamblers induced in a neutral or happy state emerged, whereas regular gamblers induced in a sad state played more than non-regular ones. Furthermore, regular gamblers' emotional

[44] At a neural level, the major differences were recorded during the initial phase of the scenarios, before they consciously indicated the variations in emotional and motivational states. In the gambling-scenarios, pathological gamblers showed a reduced activity of the orbitofrontal cortex, base ganglia and thalamus compared to the control group, while no differences were found between the two groups during the viewing of the sad and happy scenarios. In addition, in the final part of the sad scenarios, pathological gamblers showed a reduced right frontal gyrus activity, while there was no difference between the two groups during the viewing of the end of the happy scenario. In the final part of gambling-scenarios, where stimuli were more intense, pathological gamblers showed a reduced activity of the ventricular-anterior cingulate cortex compared to the control group.

assessments at the end of the game were linked to winnings. Those who lost were less happy at the end than during the game, compared to both those who won and non-regular gamblers. Instead, non-regular gamblers' emotional evaluations were not dependent on the winnings and only slightly varied in the interval from during to the end of the game.

More recently, Mishra et al. (2010) investigated the effect of the induction of emotional states on gambling behaviour at Video Lottery Terminals (winning amount, game duration, time spent to finish credit) while participants (non-problematic, low-risk, and problem gamblers) were observed (by a man or a woman) or not. Emotional induction (positive, negative, neutral) took place with the *autobiographical recall technique* combined to the listening of instrumental music. Results showed that the induced positive or negative emotional state did not affect the subsequent gambling behaviour. Regardless of the severity level of the gambling problem, the emotional state did not affect the time spent playing or the amount won. Differences in emotional state levels were found only after the game. Regardless of the gambling severity, participants induced in an emotional or neutral state showed an increase of negative emotional state levels and a decrease in positive ones compared to participants induced in a negative one. Moreover, differently from the positive state levels, the negative ones after playing were higher than before. In addition, participants spent less time playing when a woman observed them rather than when they were not observed. Instead, Munoz et al. (2010) investigated, in Video Lottery Terminals players, the effect of a threatening stimulus different in threat gradient (weak, moderate, strong), coming from two different sources (medical or related to the game) on seven different variables, measured through the answers to seven questionnaires.[45]. Participants' answers indicated that higher levels of stimulus threats were associated with high levels of information processing depth. The latter also related to the gambling involvement and to the medical source. Moreover, the most involved players showed higher fear levels. The more people were involved in the gambling, the more they felt vulnerable.

[45] The seven dependent variables were the cognitive assessment of the threat (perceived severity and vulnerability), feeling fear, information processing, source reliability, change of attitude, behavioural intent, and involvement.

4.3. Emotions and physiology: the physiological components of primary emotions

The interest for the role of the physiological components in emotional processing has given rise to a large body of research (Ekman et al., 1983; Bernston et al., 1991; Loewwnstein, 1996) that focused on variations in the parameters (heart rate, skin conductance, body temperature, muscular and respiratory activity) reflecting the action of the autonomic nervous system (SNA).

Although some studies found evidence for a specificity of activation of the autonomic system during emotional states (Ekman et al., 1983; Christie and Friedman, 2004; Stemmler et al., 2001), in literature there is no agreement on the definition of typical patterns of physiological activation of emotional states (Cacioppo et al., 2000; Mauss et al. 2005). This disagreement also seems to depend on the emotion induction procedure (Quigley and Barret, 2014).

The physiological response in *anger*-inducing situations seems to be related to a pattern of reciprocal activation of the sympathetic nervous system and increased respiratory activity (e.g. faster breathing). Studies investigating the physiological responses to the induction of the anger by the autobiographical recall technique (Prkachin et al., 1999; Neumann and Waldstein, 2001; Hamer et al., 2007) found some cardiovascular effects characterized by *increased heart rate* (HR) and systolic and diastolic *blood pressure*[46]. However, the induction of anger through the viewing of movies or images of facial expressions with angry content results in a *reduction* in heart rate (Christie and Friedman, 2004). Moreover, studies investigating the electro-dermal activity related to anger (Tsai et al., 2002; Marci et al., 2007; Rochman and Diamond, 2008) found an *increase* both in skin conductance levels (SCLs) and in skin conductance responses (SCRs).

As regards the physiological pattern of *fear*, the study of Aue et al. (2007), where the emotional induction occurred with autobiographical recall, found an *increase* in *HR*. However, studies where induction of fear occurred through the movies viewing found a

[46] The study of Stemmler et al. (2007) found the influence of motivation on HR in anger: when motivation leads to contact, HR is unchanged, whereas when motivation tends to withdrawal, HR decreases.

reduction in HR (Fredrickson and Levenson, 1988, Theall-Honey and Schimidt, 2006). Studies investigating the electro-dermal activity related to fear found, regardless of the emotional induction procedure, an increase in both SCLs (Christie and Friedman, 2004; Williams et al., 2005; Gilissen et al., 2007, 2008) and the SCRs (Collett et al., 1997; Stemmler et al., 2001). The study of Van Oyen et al., 1995, where fear was induced through viewing images, showed an increase in HR but unchanged SCLs. Other studies found a reduction in the HR associated with an increase in SCRs (Bernat et al., 2006; Codispoti and De Cesarei, 2007) or a reduction in SCLs (Stemmler, 1989; Krumhansl, 1999) [47].

Studies investigating the physiological components of *sadness* showed a heterogeneous pattern of sympathetic and parasympathetic system activation, depending both on the emotional induction technique and on the presence of the *weeping* variable. Generally, two classes of physiological activity emerge from the emotional induction of sadness: an *activating* response and a *deactivating* one. The former, corresponding to the physiological response of *sadness with tears*, appears to be characterized by an increase in the sympathetic cardiovascular system (Levenson et al., 1990; 1991; 1992) and by heterogeneous variations in SC. Specifically, participants who cried viewing videos reported an *increase* in *HR* (Luminet et al., 2004; Kunzmann and Gruhn, 2005). Such responses were associated with *increased* (Ritz et al., 2000; Tsai et al, 2003; Vienna and Tranel, 2006) or *unchanged* (Chan and Lovibond, 1996) *SCLs*. Even when the emotional induction occurred through the autobiographical recall, several studies found an increase in HR associated with increased (Ekman et al., 1983; Rochman and Diamond, 2008; Tsai et al., 2002) or unchanged (Marci et al., 2007) SCLs. In the deactivating responses of sadness, which overlapped the physiological responses to *sadness with no cry*, a *decrease* in *HR* (Britton et al., 2006; Gruber et al., 2008; Tsai et al., 2000) with a *reduction* both in *SCLs* (Tsai et al., 2000; Marsh et al., 2008) and *SCRs* (Britton et al., 2006) was found. However, in the study of Fredrickson and Levenson (1998) no changes in HR were found.

[47] Further studies found that increased HR was accompanied by an increase in blood pressure (Montoya et al., 2005; Rainville et al., 2006) or in respiratory activity (Pauls and Stemmler, 2003; Rainville et al., 2006).

As regards the pattern of *joy, s*tudies using the autobiographical recall technique (Sinha et al., 1992; Neumann & Waldstein, 2001) found a physiological response characterized by an *increase* in *HR*. In addition, research conducted by Vrana, where participants were exposed to standardized images of joy, showed either *increased* (Vrana & Gross, 2004) or remained unchanged (Vrana 1993; Vrana & Rollock, 2002) *SCLs*.

4.4. Emotions, arousal, and gambling

Gambling entails reactions to risk and uncertain events, as well as a continued exposure to activating environment stimuli. Arousal, in both subjective and objective side, is currently considered an integral component to the onset and maintenance of gambling behaviour (Blaszczyncky & Nower, 2002; Sharpe, 2002).

A growing body of research indicates that gamblers showed increased physiological levels of arousal when involved in a gambling environment, during real (Anderson and Brown, 1984) or experimental (Leary and Dickerson, 1985; Rockloff et al., 2007) settings. The seminal study conducted by Anderson and Brown (1984) examined the heart rate (HR) during blackjack game in both a real and a laboratory casino (12 students tested in a laboratory and 12 gamblers in both laboratory and real casino). They found that gamblers reported higher HR in the real casino than in laboratory, while no differences between gamblers and students emerged in laboratory. Moreover, gamblers showed a positive correlation between the bets carried out and the increase in HR in the real casino[48]. Subsequently, the studies of Meyer et al. (2004) and Krueger et al. (2005) extended Anderson and Brown's findings. Meyer et al. (2004) measured HR[49] in problem gamblers and non-problem gamblers during blackjack playing in a casino and control setting. They found increases in HR, and cortisol levels, in both groups at the onset of the game in the actual session; however, gamblers showed significantly higher levels over the entire gambling session. In addition, the level of

[48] The authors stated the importance of winning or losing big sums of money for increased HR.
[49] As well as salivary cortisol levels and the endocrine ones of norepinephrine and dopamine.

participants' gambling severity correlated negatively with the HR during the control condition whereas during the experimental one did not[50]. Similar results emerged from the Krueger et al.'s (2005) study, conducted only with gamblers, without control group: gamblers showed increased HR, as well as cortisol levels, during blackjack playing in a casino setting where they had to bet their own money. Conversely, when they were required to play cards in a laboratory without betting money, they did not exhibit increases in physiological arousal. In addition, more impulsive gamblers showed increased HR (but not cortisol levels), during the gambling session. Furthermore, a positive relationship between impulsivity scores and gambling severity was found.

The first study in which gamblers exhibited an increased HR even in a laboratory setting has been that of Leary and Dickerson's (1985). They compared the HR of high and low frequency gamblers, before, during and after playing video poker in a laboratory. They found that, although HR between the two groups did not differ during the baseline, both groups exhibited increases in HR during the gambling task that, compared to low-frequency gamblers, was greater in high-frequency gamblers. In addition, compared to the high-frequency gamblers, low-frequency gamblers showed a decreased subjective arousal during and after playing[51].

However, other psychophysiological studies comparing problem gamblers and non-gamblers or high vs. low frequency gamblers in laboratory or real settings found discordant results.

Sharpe et al. (1995) investigated in a laboratory study which stimulus related to gambling increased arousal. They compared the performance of three groups of poker gamblers (pathological, high and low frequency) in five tasks where skin conductance levels (SCL) and HR were measured. One task required participants to watch a video of a poker game and to imagine playing, whereas a second was the distracting version of the previous one (participants also had to count the wins). The other three tasks required to watch a horse-

[50] Dopamine levels were significantly higher in gamblers during the casino task compared to non-problem gamblers.
[51] As high-frequency gamblers played more and lost more money than low-frequency gamblers, data comparison at the end of the game was not possible.

race video, to imagine a past personal win and, in a neutral condition, to count letters of the alphabet. The results showed differences between pathological and low/high-frequency gamblers. SCLs in the pathological gamblers' group were higher than in the other two groups during the viewing of the poker game, with respect to the neutral condition and to the horse racing video. Low and high frequency gamblers' groups did not differ in any of the physiological measures. In addition, while recalling a personal win, pathological gamblers showed SCLs higher than the other two groups. Instead, HR did not differ among the groups in any condition. Griffiths' (1995) study compared high and low frequency gamblers who were given a sum to play with a slot machine in a naturalistic setting. Participants were encouraged by instructions to play at least 50 games, and then they could decide to keep playing or to withdraw the winning sum. The HR was measured before, during and after the game. The results showed that the two groups did not differ in HR in any of the three intervals: both groups showed increased HR during the game and higher HR after the game compared to the beginning of the game.

In a real setting, Coventry & Norman (1997) measured HR of off-course horse races gamblers, before, during and after betting their own money. The HR was measured every 30 seconds at different stages of the betting process. The results showed that, although there were no differences between high and low frequency gamblers, the HR was higher during bet placement and at the end of races. In addition, although to a lesser extent, HR rate was higher in gamblers who were winning than those who were losing. Subsequently, in a laboratory study, Coventry & Norman (1998) examined the gamblers' HR in a task in which, at each trial, they had to choose which of the four turtles would win by first reaching the finish line. The outcomes of their betting were presented in ascending, descending or random order. Apart from a slight increase in HR, particularly in early trials, the two groups did not show differences. In addition, the order of the presentation of wins and losses had no effect on HR. On average, wins increased HR whereas losses did not.

Little differences between compulsive gamblers and the control group were found in the laboratory study conducted by Blanchard et al. (2000), which compared the SCLs, HR and blood pressure in a group of seven compulsive gamblers with a control group paired by sex and age. Participants were required to listen to personally meaningful gambling audiotapes, fear audiotapes, and to carry out an arithmetic mental task. The two participants' groups only differed in the HR, which was higher in the gamblers than the control group during the gambling audiotapes.

Finally, in the laboratory study of Rockloff et al. (2007), gamblers (with many vs. few problems) were presented with a noise increasing the skin conductance responses (SCRs), prior to, and at various intervals, a simulated slot machine game. In a control condition, no noise was presented. Results revealed that gamblers with many problems, opposed to gamblers with few problems, showed smaller bet size in the noise condition compared to the control one. The authors argued that arousal might provide different signals to gamblers: gamblers with many problems might associate arousal with losing money, while gamblers with few or no problems may associate it with excitement due to the winning.

Instead, some studies found that the measures of subjective arousal did not necessarily correlate with objective measures of physiological arousal. For example, Roby and Lumley (1995) found a decreased subjective arousal in high-frequency gamblers compared to low-frequency ones. They assessed the effect of an accuracy feedback and the possibility to win or lose money on HR, SCL and skin temperature, during a laboratory-gambling situation. Participants had to choose which of the two lights below a panel would light. At the end of each trial, in a condition the participants received a feedback on their accuracy, whereas in a second one they had to make a bet. Results showed higher SCL and HR in the latter condition. In addition, high-frequency gamblers showed a decrease in subjective pleasure and skin temperature. In a field study conducted on a female sample, Coventry & Constable's (1999) found a non-significant correlation between HR and perceived arousal. Participants (low vs. high frequency gamblers) played a slot machine with their own money. No difference between low and high frequency gamblers was found. However, HR was higher during the game than both before and after. In addition, the HR was higher in gamblers who won, both during and after the game, than in those who lost. In addition, they found a negative correlation between gambling frequency and sensation seeking scores, measured by Zuckerman's SSS (1979). Diskin and Hodgins (2003) showed that both pathological and non-pathological video-lottery gamblers exhibited a similar level of HR and SCL (as well as muscle tone) in response to an imaginary gambling task.

However, during the same task, pathological gamblers report greater levels of subjective arousal compared to non-pathological gamblers. Ladouceur et al. (2003) compared occasional (those who played less than once a month) and regular (at least once a month) gamblers measuring differences in HR responses to video lottery games in a laboratory setting. In two conditions, participants were offered the chance to win either real money or worthless credits. They found no difference due to the gambling severity. Participants exposed to high-winning expectations experienced increased HR prior to, and during, the gambling session compared to those exposed to a low one. In addition, self-reports indicated the expectancy of winning real money to be exciting, not playing the game for fun.

Finally, in a study with healthy volunteer participants, Studer et al. (2016) investigated SC and HR sensitivity to winning odds during bet selection. Participants took part in the Roulette Betting task (Studer and Clark, 2011), where the winning probability and the type of bet selection varied. At each trial, participants were presented with a wheel of 10 blue (winning) and red (losing) slots, whose proportion changed according to the winning probability (40% 60% 80%). In one condition, participants could choose between three different bets (10, 50, 90 points) while in another condition the three bets were identical (50, 50, 50). The task of the participants was to bet at each trial trying to accumulate as many points as possible. The results showed that SC and HR accelerations were susceptible to winning probability, particularly in the condition where it was possible to choose the bet. In fact, during the betting selection phase, the SC increased as the winning probability increased in the active choice condition, while it diminished in the inactive choices. Instead, HR only increased as the winning probability in the active choice increased.

Overview of the study

The present study aimed to examine the effect of positive and negative emotional states on decision making of problem and non-problem gamblers in four fictitious gambling tasks.

Specifically, the study investigated (i) whether the activation of incidental discrete positive/negative emotions was accompanied by a change of physiological parameters, (ii) whether the induced emotional states affected the participants' bet choice and (iii) whether such choices were influenced by physiological arousal. Finally, it investigated whether such effects were present to a different extent in problem and non-problem gamblers.

To this end, a quasi-experiment with a mixed design was created - described in the materials and procedure section - with two between-subject independent variables, one of which (*emotion*) was manipulated whereas the other (*gambling status*) was not, and two within-subjects variables (*winning probabilities* and *bet provenance)*. In addition, throughout the experimental session, two physiological indices of emotional activation, such as *skin conductance* (SC) and *heart rate* (HR), were recorded with the biofeedback technique.

After the emotional induction, participants took part in four decision-making tasks, each of them representing a computer-simulated bet game that differed for the supposed *provenance of the hypothetical money* used to play (experimenter or oneself) and *winning probabilities* (fixed or varying): in each game participants had to decide whether and how much to bet.

Depending on the opposite theoretical perspectives, different results could be expected from the effect of emotional induction. According to the *Affect Infusion Model* (AIM, Forgas, 1995), the activation of negative emotional states should produce more prudent choices than the one of a positive emotional state, which should generate a more risky behaviour. Conversely, according to the *Mood Maintenance Hypothesis* (MMH, Isen, 1978), the activation of a negative emotional state should generate a behaviour riskier than the one triggered in a positive emotional state, which should produce more cautious choices. Differently, the *Appraisal Tendency Framework* (ATF, Lerner & Keltner, 2000; 2001) predicts that the activation of negative emotions of the same valence should produce different effects on choices: more specifically, *anger*, *sadness*, *happiness* and *joy* should generate more risky choices compared to *fear*.

As to the effect of physiological arousal on decision-making of problem and non-problem gamblers, empirical evidence is far from being congruent, as the literature review has shown: so, no specific hypotheses were formulated on this topic.

However, it was expected that this study could contribute to better understand: (i) whether there is congruence between the subjective perception of emotional states and the physiological indices of emotional arousal, (ii) whether problem and non-problem gamblers are similar or different in emotional self-assessment and in emotional arousal, (iii) whether the assumed effect of perceived emotional activation on decision-making was mediated by emotional arousal.

Also in this study, no monetary incentives were contemplated. However, through the use of the "bet provenance" variable, participants were asked to imagine what they would do if they had been invited to play in the classic experimental settings (i.e. with money given by the experimenter) or if they had to imagine playing in real life (that is with their own money). Although in both cases they had to simulate (imagining that money was their own or given by the experimenter), it was assumed that people would vividly imagine situations and therefore be able to make choices "as if" they were really in those situations. In the games that are supposed to have ecological validity, participants play with money made available by the experimenter and not with their own money. Therefore, the classical experimental settings probably lead to overestimating risk proneness (precisely because they do not take into account the provenance of money).

Experiment

Participants

Differently from the previous two studies, where the sample was composed of 320 participants, in this study the sample was composed of 300 participants aged between 18 and 68 years (mean = 33.87, SD = 10.65). This reduction was due to the fact that about ten problem gamblers did not consent to the use of electrodes to assess emotional arousal: consequently the number of participants per experimental condition was reduced and also the non-problem gamblers sample was diminished.

The participants' features and the recruitment procedure were already descripted in the study on the illusion of control. Moreover, in the informed consent form for this study, in which participants were invited to take part in an emotions and decision-making research, it was specified that, during the experiment, heart rate and skin conductance would be measured through electrodes in order to evaluate whether their emotional state modified. As it was already told, those who did not accept the use of electrodes left the experimental session.

Design

The 5 x 2 x 2 x 2 quasi-experimental mixed design involved two between-subjects variables – *emotion* (anger, fear, sadness, joy, control) and *gambling status* (problem gamblers vs. non-problem gamblers) – and two within-subjects variables - supposed *bet provenance* (experimenter vs. participant) and *winning probability* (fixed vs. varying) - whose intersection gave rise to the 4 games played by each participant. The 5 categories of the emotion variable corresponded to the four emotions (anger, fear, sadness, and joy) that it was intended to induce by the autobiographical recall technique, and the control condition in which no emotion was induced. The dependent variable was the *bet choice* in the four bet games.

Materials and Procedure

Once informed about general objectives of the experiment, participants were informed that the experiment was divided into two parts: in the first, the relationship between memories and emotional states was investigated; in the latter, they were asked to make some decisions.

After reading the instructions, in order to record a resting state activity, participants were required to look at the cross at the centre of the screen for 2 minutes (*baseline* phase). At the end of the 2 minutes, the next screen appeared automatically, and participants were asked to evaluate, through a 9-point Likert scale (1 = not at all; 9 = extremely), the intensity of six emotions, presented in a random order: *anger towards something or someone*, *fear*, *sadness*; *joy*, *satisfaction*, *serenity* (pre-emotion induction measures).

After that, depending on the experimental condition in which they were placed, participants were required to recall an autobiographical event of their life in which they had felt *anger*, *fear*, *sadness* or *joy*. More specifically, participants were required to relive in their mind, for 1 minute, as intensely and in detail as possible, an episode of their life in which they had felt *anger, fear, sadness* or *joy*. Differently, participants in the *control* condition were required to rethink for a minute at events of their life in which they had not felt any particular emotion (*emotional induction* phase).

In order to check whether the experimental manipulation had been successful, after the induction phase, participants evaluated their emotional state using the same procedure of the first emotional assessment (post-emotion induction measures). At the end of the second emotional self-evaluation, participants were presented with *four* decision-making tasks in computer-simulated bet *games*, each of which with *five choice options*. The order of the games and of the choice options was random.

In the first task (Game 1*: fixed* probability */ experimenter* bet-provenance), participants were told to imagine they had a hypothetical budget of 10€ available for playing “heads or tails”. The instructions specified that winning odds were 50%. The game rules explained they had the possibility to bet the entire available sum or just a part. They also specified that the size of the hypothetical reward varied depending on the bet: in case of winning, the expected reward was added to the initial 10€, minus the bet; in the case of losing, the bet was deducted from the initial sum. There was also the possibility of not betting: in that case, 1.5 € was deducted from the sum available (so they had 8.5 € left). Once participants accepted to play, they were presented with *five options*, which *varied* for the *wager size* while the *winning probability* was kept *constant* (50%). Participants’ task was to choose on which option to bet (table n.1).

In the second task (Game 2*: varying probability / experimenter bet-provenance*), participants were told to imagine they had a hypothetical budget of 10€ available to play a “card guessing game”. The game rules explained that the *winning probability* and related *rewards varied* as a function of the number of cards that they chose to turn in order to find the winning card. Participants had the possibility to bet the available sum in a gamble where the winning probability and the resulting reward varied. They also had the possibility of not betting: in that case, 5 € was deducted from the sum available (so they had 5€ left). Once participants accepted to play, they were presented with five options *varying* in *winning probability* and *reward size*, while the *wager size* was kept *constant*. Participants’ task was to choose on which option to bet (table n.2).

The third task (Game 3*: fixed* probability */ participant* bet-provenance) had the same structure of game 1, except for the fact that participants were asked to *imagine to bet their own money*, instead of having a hypothetical budget offered by the experimenter (table 1).

Analogously, the fourth task (Game 4*: varying* probability / *participant* bet-provenance) had the same structure of game 2, except for the fact that participants were asked to *imagine to bet their own money* (3€), instead of having a hypothetical budget offered by the experimenter (table 2).

As mentioned previously, in each game the participants' task was to choose whether and on which option to bet. Responses were coded on a 5-point Likert scale, from "very cautious" (choosing not to bet), to "very risky" behaviour (choosing to bet the entire amount available).

The choice options had the same expected value: the mean of wins and losses, weighted as a function of the probability.

Table 1: Structure of the tasks 1 and 3 with their five response options.
(Game 1 = fixed-probability / experimenter bet-provenance.
Game 3 = fixed-probability / participant bet-provenance).

Game 1	**Game 3**
No bet: you will leave with 8.5€	**No bet**
Bet 2.5€ →Winning 5€: if you win then you will have 12.5€ if you lose then you will have 7.5€	**Bet 1.5€ →Winning 3€** if you win then you will have 3€ if you lose then you will have -1.5€
Bet 5€ → Winning 10€: if you win then you will have 15€ if you lose then you will have 5€	**Bet 3€ → Winning 6€** if you win then you will have 6€ if you lose then you will have -3€
Bet 7.5€ → Winning 15€: if you win then you will have 17.5€ if you lose then you will have 2.5€	**Bet 4.5€ → Winning 9€** if you win then you will have 9€ if you lose then you will have -4.5€
Bet 10€ → Winning 20€ if you win then you will have 20€ if you lose then you will have 0€	**Bet 6€ → Winning 12€** if you win then you will have 12€ if you lose then you will have - 6€

In game 1, the bet options had the same expected value, i.e., the mean of wins and losses, weighted as a function of the probability: (12.5 x 0.5 + 7.5 x 0.5) = (15 x 0.5 + 5 x 0.5) = (17.5 x 0.5 + 2.5 x 0.5) = (20 x 0.5 + 0 x 0.5) = ***10.***

In game 3, the expected value of the bet options was in progression: (3 x 0.5 + -1,5 x 0.5) = ***0.75***; (6 x 0.5 + -3 x 0.5) = ***1.5***; (9 x 0.5 + -4.5 x 0.5) = ***2.25***; (12 x 0.5 + -6 x 0.5) = ***3***.

Table 2: Structure of the tasks 2 and 4 with their five response options.
(Game 2 = varying-probability / experimenter bet-provenance.
Game 4 = varying -probability / participant bet-provenance).

Game 2	**Game 4**
No bet (you will leave with 5€)	**No bet**
8 cards: Probability 80% →Win 12.5€	**8 cards: Probability 80% →Win 3.75€**
6 cards: Probability 60% →Win 16.5€	**6 cards: Probability 60% →Win 5€**
4 cards: Probability 40% →Win 25€	**4 cards: Probability 40% →Win 7.5€**
2 cards: Probability 20% →Win 50€	**2 cards: Probability 20% →Win 15€**

Also in games 2 and 4, the choice options had the same expected value. Game 2: (0.8 x 12.5 + 0.2 x 0) = (0.6 x 16.5 = 0.4 x 0) = (0.4 x 25 + 0.6 x 0) = (0.2 x 50 + 0.8 x 0) = *10.* Game 4: (0.8 x 3.75 + 0.2 x 0) = (0.6 x 5 + + 0.4 x 0) = (0.4 x 7.5 + + 0.6 x 0) = (15 x 0.2 + + 0.8 x 0) = *3.*

Acquisition of physiological data

A ProComp 5 Infiniti BioGraph software version 6.0.4 (Thought Technology Ltd.) was used to measure skin conductance and heart rate. Skin conductance was measured using two electrodes attached to the distal phalange of the index and ring fingers of the non-dominant hand, and heart rate using an electrode attached to the distal phalange of the middle finger of the non-dominant hand. Physiological data was measured continually using a laptop (Dell Inspiron 13), on which the software was installed, receiving the transmitted signal from the laptop (Hp Compaq 6730s) on which the participant conducted the experimental task. Such signal, by a polar interface port, aimed to scan the temporal windows in which the participants' responses to the task took place.

Extraction of physiological data

Skin conductance and heart rate data were extracted for each participant. A 1-minute window immediately preceding the first emotional assessment served as baseline. In order to investigate whether physiological changes took place during the emotional induction, another 1-minute window was extracted from the emotional induction phase. Moreover, four 5-seconds windows were extracted in order to investigate the physiological arousal immediately before the choice in the four tasks. For each recorded session, every noise was cleaned with a manual procedure of artefacts rejection.

Results

Analogously to the previous two studies, the data were first analysed without the two covariates, i.e. the BSSS and BIS_11 scores, and then with the two covariates in order to examine their impact on the results.

- ***Manipulation check***

Three mixed ANOVAs were conducted to check whether the experimental manipulation was effective in modifying the intensity of participants' emotional state (through three indices: self-reported emotions, HR and SCL) after emotion induction, and to investigate putative differences between problem gamblers and non-problem gamblers.

It should be remembered that, before and after the emotion induction, participants assessed the intensity of six emotions: *anger towards something or someone*, *fear*, *sadness*, *satisfaction*, *serenity* and *joy*, in a 9-point Likert scale (1 = not at all; 9 = extremely). Henceforth, the term *condition* will be used to indicate the five emotions inducted through autobiographical recall, whereas the term *emotion* will be used to indicate the six self-assessed emotions.

The physiological indices of physiological arousal (HR and SCL) considered for the manipulation check were the following: a *1-minute window* immediately preceding the first emotional assessment (which served as *baseline*) and a *1-minute window* extracted from the *emotional induction* phase.

- ***Self-reported emotion intensity***

To analyse the putative changes in self-report assessment before and after emotion induction in function of the five experimental *conditions* and *gambling status*, a 5 (*condition*: control, anger, fear, sadness, joy) x 2 (*gambling status*: problem gamblers vs. non-problem gamblers) x 2 (*time*: before vs. after induction) x 6 (*emotion*: anger towards something or someone, fear, sadness, satisfaction, serenity, joy) mixed ANOVA was performed. The between-subject variables were *condition* and *gambling status*, whereas the within variables were *time* and *emotion*.

As expected, results revealed the three-way interaction *condition x emotion x time*, $F_{20, 1445} = 15.92$; $p < .000$; $p\text{-}\eta^2 = .181$, whereas the four-way interaction *condition x gambling status x emotion x time* was not significant ($F_{20,1445} = 1.44$; $p = .094$; $p\text{-}\eta^2 = .02$). The latter finding revealed that the emotion induction did not differ between problem gamblers and non-problem gamblers. The three-way interaction *condition x emotion x time* was examined through the simple effects analysis with Bonferroni adjustment for multiple comparisons. Results revealed that the *anger* condition led to a significant increase of *anger*, *fear* and *sadness* and to a significant decrease of *joy*. In the *fear* condition, participants experienced a significant higher intensity of *fear* and a significantly lower intensity of *joy*. In the *sadness* condition, *sadness* increased significantly while *serenity* and *joy* decreased. The *joy* condition showed a significant increase of *anger*, *joy* and *satisfaction* while *sadness* decreased. Finally, in the *control* condition, changes in the intensity of the emotions between pre- and post-induction were not observed. Such results indicated that the experimental manipulation was successful.

Table 1 shows the pre/post induction means (with SD) of emotion intensity in function of *condition* and *time.*

Table 1– Means (and s.d.) of self-report emotions before and after emotions induction in five experimental conditions.

	Experimental Conditions									
	CONTROL		ANGER		FEAR		SADNESS		JOY	
Emotions	Before	After	Before	After	Before	After	Before	After	Before	After
Anger	3.06 (.25)	3 (.26)	3.06* (.25)	4.78* (,26)	3.04 (.25)	2.77 (.26)	3.41 (.25)	3.8 (.26)	3.38 (.25)	2.75 (.25)
Fear	2.06 (.18)	1.95 (.21)	1.8* (.18)	2.3* (.21)	1.69* (.18)	2.98* (.21)	2.55 (.18)	2.2 (.21)	1.78 (.18)	1.46 (.21)
Sadness	2.93 (.22)	3.21 (.24)	3.05* (.22)	3.65* (.24)	3.94 (.22)	4.08 (.24)	2.71* (.22)	4.23* (.24)	2.71* (.22)	1.81* (.24)
Satisfaction	6.25 (.26)	6 (.27)	5.1 (.26)	5.35 (.27)	4.06 (.27)	4.37 (.28)	4.9 (.26)	4.53 (.27)	5.31* (.26)	5.8* (.27)
Serenity	5.48 (.23)	5.63 (.23)	5.21 (.23)	4.9 (.23)	4.52 (.23)	4.24 (.23)	5.08* (.23)	4.4* (.23)	5.65 (.23)	5.55 (.23)
Joy	4.73 (.23)	4.75 (.23)	4.65* (.24)	3.31* (.23)	3.44* (.23)	2.88* (.23)	3.5* (.23)	2.88* (.23)	3.78* (.23)	5.2* (.23)

The ANCOVA[52] testing the impact of the BSSS and BIS-11 scores as covariates on the self-assessments of participants' emotions did not show different effects from the ones above described.

52 Also in this study the ANCOVAs were performed after checking that the assumption of homogeneity of regression slopes was respected.

- ***Heart Rate (HR)***

To investigate putative HR variations during the emotion induction as a function of *condition* and *gambling status*, a 5 (*condition*: control, anger, fear, sadness, joy) x 2 (*gambling status*: problem gamblers vs. non-problem gamblers) x 2 (*time*: HR before vs. after induction) mixed ANOVA was conducted, with *condition* and *gambling status* as between-subjects variables, and *time* as within-subjects variable.

The results showed a two-way interaction between *condition* and *time*, $F_{4,290} = 5.369$; $p <.000$; $p\text{-}\eta^2 = .069$, and a three-way interaction *gambling status x condition x time*, $F_{4,290} = 2.896$; $p < .05$; $p\text{-}\eta^2 = .038$. Such interactions were examined through the analysis of simple effects with Bonferroni correction.

The two-way interaction *condition* x *time* was due to the fact that HR means significantly *increased* in *anger, fear* and *joy* conditions after the emotional induction, whereas in the control and *sadness* conditions they did not differ significantly between the two temporal windows.

The three-way interaction *condition x gambling status x time*, where the two-way interaction *condition* x *time* was included, showed the different HR means, pre/post emotional induction, as a function of the *experimental conditions* and *gambling status*. More specifically, in the *anger* condition, non-problem gamblers experienced significantly increases of HR after the emotional induction (p< .000), whereas problem gamblers did not report differences between the two temporal intervals (p=.438). Also in the *sadness* condition, only non-problem gamblers (p< .05) showed a decrease in HR after emotional induction, whereas problem gamblers did not show any difference (p=.354). Instead, both problem gamblers and non-problem gamblers experienced significant increases in the HR means after the emotion induction in the *fear* (p<.005 and p<.05, respectively) and *joy* (both p<.005) conditions. In the *control* condition, both participants' groups did not reveal differences in HR pre/post emotional induction.

The same results were obtained from ANCOVA.

HR means and S.D. pre/post emotional induction as a function of the *condition* and *gambling status* are reported in table 2.

Table 2 Means and S.D. of Hearth Rate (HR beats/min) in the different experimental conditions as a function of the *Gambling status* and emotional induction (before and after).

	CONTROL		ANGER		FEAR		SADNESS		JOY	
	NPG	PG	NPG	PG	NPG	PG	NPG	PG	NPG	PG
Before	76.13 (1.56)	75.79 (1.57)	78.5* (1.56)	76.93 (1.56)	78.17* (1.56)	73.73* (1.56)	78.89* (1.56)	77.55 (1.56)	79.04* (1.56)	77.67* (1.56)
After	77.28 (1.96)	75.83 (1.96)	84.27* (1.96)	77.99 (1.96)	81.64* (1.96)	77.78* (1.96)	75.67* (1.96)	78.82 (1.96)	83.19* (1.96)	81.78* (1.96)

NPG: Non-problem gamblers; PG: Problem gamblers

- ***Skin conductance levels (SCL)***

To analyse whether SCL changed during the emotional induction as a function of *condition* and *gambling status*, a 5 (*condition*: control, anger, fear, sadness, joy) x 2 (*gambling status*: problem gamblers vs. non-problem gamblers) x 2 (*time*: SCL *before vs. after* emotional induction) a mixed ANOVA was conducted. *Condition* and *gambling status* were the between-subjects variables and *time* was the within-subjects variable.

The results revealed two two-way interactions: c*ondition* x *time*, $F_{4,290} = 4.571$; $p<.001$; $p\text{-}\eta^2 = .059$, and *gambling status x time*, $F_{1,290} = 10.542$; $p < .05$; $p\text{-}\eta^2 = .035$.

Such interactions were examined through the simple effects analysis with Bonferroni correction. Results showed that the c*ondition* x *time* interaction was due to the fact that, in the *anger* (p<.000), *fear* (p<.05) and *joy* (p<.000) conditions, SCL *increased* after emotional induction, whereas in the *sadness* (p=.217) and in the *control* (p=.114) conditions SCL did not vary significantly between the two the temporal intervals.

The *gambling status x time* interaction showed that both participants' groups experienced a significant increase in SCL after emotional induction. However, in non-problem gamblers group (p<.000) this increase was much higher than in the problem gamblers' group (p<.05).

Once again, when BSSS and BIS scores were entered into the ANCOVA model as covariates, results did not show different effects.

Table 3 shows the means and s.d. of SCL values pre/post emotional induction as a function of *condition* and *gambling status*.

Table 3 - Means (and s.d.) of SCL (μS) before and after the emotional induction in different experimental conditions as a function of the *gambling status*.

	CONTROL		ANGER		FEAR		SADNESS		JOY	
	NPG	PG	NPG	PG	NPG	PG	NPG	PG	NPG	PG
Before	3.18 (1.55)	2.82 (.79)	3.57 (1.74)	3.27 (1.73)	2.83 (1.16)	2.67 (.62)	3.39 (1.84)	2.93 (1.25)	3.04 (.98)	2.86 (1.11)
After	3.31 (1.62)	2.97 (.95)	4.38 (2.33)	3.63 (1.98)	3.31 (1.51)	2.61 (.66)	3.53 (2)	3.02 (1.43)	3.5 (1.26)	2.79 (.75)

NPG: non-problem gamblers; PG: problem gamblers.

- ***Effect of independent variables on bet choice***

In order to investigate the incidence of the independent variables *condition* and *gambling status* on the *bet choice* in the four games, a mixed ANOVA was performed. The four games were entered in the analysis based on the two variables by which they were composed: *money provenance* (experimenter vs. oneself) and *probability* (fixed vs. varying). *Bet choice* was a continuous variable whose values went from 1 (choice of not betting) to 5 (highest bet amount). Consequently, a 5 (*condition:* control, anger, fear, sadness, joy) x 2 (*gambling status:* problem gamblers vs. non-problem gamblers) x 2 (*money provenance:* experimenter vs. oneself) x 2 (*probability:* fixed vs. varying) mixed ANOVA was performed. *Condition* and *gambling status* were the between-subjects variables; *money provenance* and *probability* were the within-subjects variables.

Table 4 displays means and S.D. of bet choice in function of *condition* and *gambling status* in the four games.

Table 4 – Means and s.d. of *bet choice* in the four games in function of *experimental conditions* and *gambling status* (NPG=non-problem gamblers; PG=problem gamblers).

	EXPERIMENTAL CONDITIONS									
	CONTROL		ANGER		FEAR		SADNESS		JOY	
	NPG	PG	NPG	PG	NPG	PG	NPG	PG	NPG	PG
GAME I	2.31 (1.1)	2.87 (1)	2.5 (1.33)	2.67 (1.32)	1.86 (.63)	2.57 (1)	2.13 (.77)	1.93 (.9)	3.23 (1.1)	2.8 (.88)
GAME II	2.76 (1.05)	3.57 (1.07)	3.33 (.92)	3.7 (1.29)	2.14 (.91)	3.23 (.93)	2.5 (1.04)	3.2 (1.18)	3.37 (1.12)	3.37 (1.21)
GAME III	1.86 (.95)	2.23 (.77)	2.03 (.92)	2.6 (1.03)	1.34 (.48)	2.13 (1.07)	1.6 (.89)	2.3 (1.2)	2.23 (.93)	2.53 (.68)
GAME IV	2.59 (.98)	3.3 (.98)	3.13 (1.4)	3.83 (1.23)	1.86 (.74)	2.93 (1.17)	2.67 (1.38)	3.1 (1.44)	3.27 (1.61)	3.27 (1.17)

Game I: fixed probability and experimenter money; Game II: varying probability and experimenter money; Game III: fixed probability and oneself money; Game IV: varying probability and oneself money

The results showed four main effects due to *condition*, $F_{4,288}$ = 10.804; p<.000; p-η^2=.13, *gambling status*, $F_{1,288}$ = 27.514; p <.000; p-η^2 =.087, *probability*, $F_{1,288}$ = 179.737; p <.000; p-η^2 =.384, and *money provenance* $F_{4,288}$ =32.165; p <.000; p-η^2 =.1.

They also showed five two-ways interactions: *condition x gambling status*, $F_{4,288}$= 2.954; p <.05; p-η^2 =.039, *gambling status x probability*, $F_{1,288}$ = 4.268; p <.05; p-η^2 =.015, *condition x money provenance*, $F_{4,288}$ = 2.56; p <.05; p-η^2 =.034, *probability x money provenance*, $F_{1,288}$ = 9.435; p <.005; p-η^2 =.032, and *gambling status x money provenance* $F_{1,288}$ = 4.184; p <.05; p-η^2 =.014. Finally, they revealed a three-way interaction: *gambling status x probability x money provenance*, $F_{1,288}$ = 4.792; p <.05; p-η^2 =.016.

The main effect of the *condition* showed that participants bet more in *joy* and *anger* conditions than in the other conditions; in the *sadness* (M=2.42) condition they bet less than in the *joy* (M=3) and *anger* (M=2.97) conditions, whereas no difference emerged with *control* (M=2.68) and *fear* (M=2.25) conditions. In the *fear* condition, they bet less than in the other conditions, except for *sadness*.

The main effect of the *gambling status* revealed that problem gamblers (M=2.9) bet more than non-problem gamblers (M=2.43). The main effect of the *probability* showed that participants bet more in the two games ("card guessing") where the winning probabilities varied (M=3.05) than in those where the winning probabilities were fixed (M=2.28). The main effect of the *money provenance* revealed that participants bet more in the two games where they had to imagine that the hypothetical money was provided by the *experimenter* (M=2.8) than in the two games where they had to assume that the hypothetical money belonged to them (M=2.54).

The main effects of the *condition*, *gambling status*, *probability* and *money provenance* were moderated by the interaction effects, examined through the analysis of simple effects with Bonferroni correction.

Concerning the two-way interaction *condition x gambling status*, problem gamblers bet significantly more than non-problem gamblers in *all* experimental conditions, except in the *joy* condition where the two groups' bets did not differ.

The *probability* x *gambling status* interaction revealed that both *problem gamblers* and *non-problem gamblers* placed higher bets in the two games where the winning probabilities varied (*card guessing game*) than in the ones where they were fixed ("heads or tails"). However, this difference was more accentuated in *problem gamblers* than in non-problem gamblers.

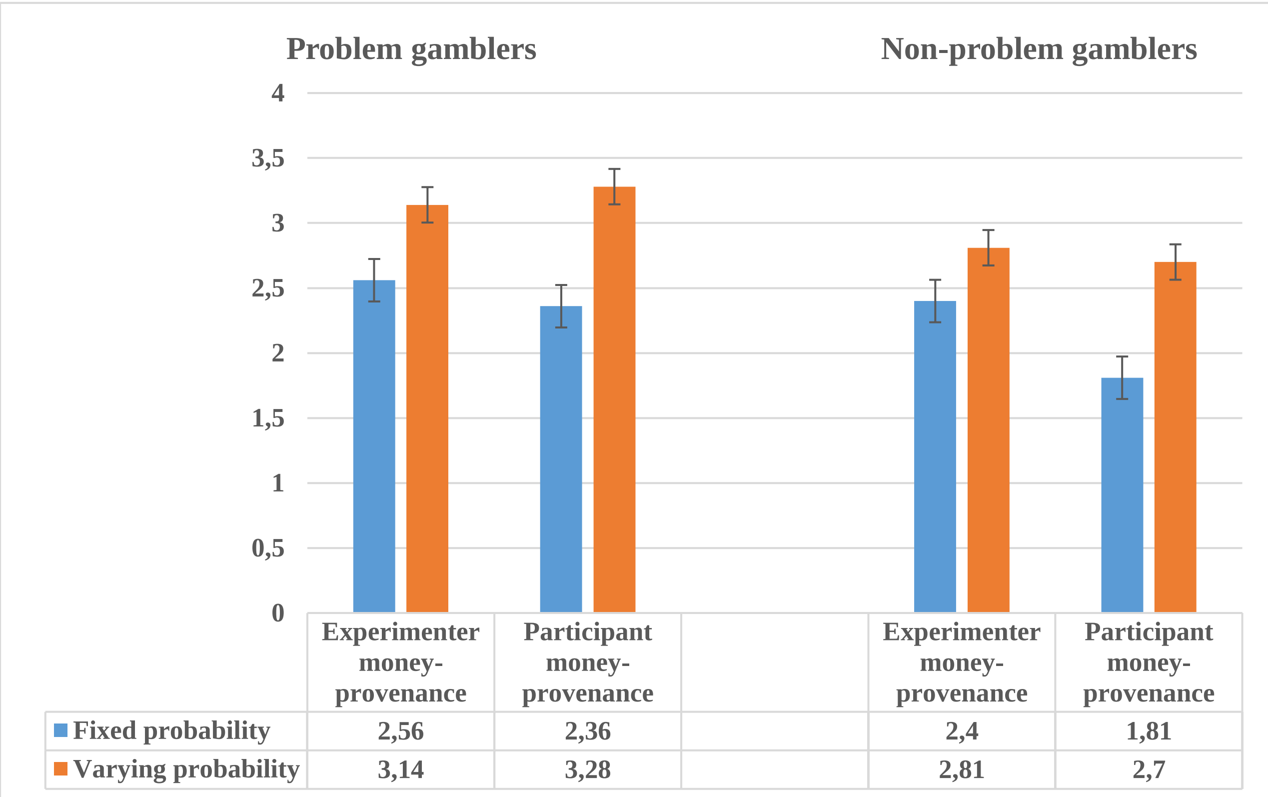
The *condition* x *money provenance* interaction showed that in the *fear, joy* and *control* conditions, participants placed higher bets when they had to imagine that the *experimenter* provided hypothetical money rather than if they had to assume the hypothetical money as their own, whereas in the *anger* and *sadness* conditions no difference emerged.

The *probability x money provenance* interaction revealed that, in the two games where the winning probabilities were fixed (*heads or tails*), participants placed higher bets when they had to imagine that hypothetical money was provided by *experimenter* (M=2.48) than when they had to imagine that hypothetical money belonged to themselves (M=2.08). Instead, in the two games where winning probabilities varied, this difference was not significant.

The *gambling status* x *money provenance* interaction showed that both *problem gamblers* and *non-problem gamblers* placed higher bets when they had to imagine that hypothetical money was provided by *experimenter* (M=2.99 and M=2.61, respectively) than they had to imagine that the money belonged to themselves (M=2.82 and M=2.25, respectively). However, this difference was more accentuated in *non-problem gamblers* ($p<.000$) than in problem gamblers ($p<.05$).

The three-way interaction *gambling status x money provenance x probability* included the main effects of *money provenance* and *probability*, and the two-way interactions *gambler status x probability*, *gambler status* x *money provenance* and *probability x money provenance.* This interaction revealed that, in the two games where winning probabilities were *fixed*, both *problem gamblers* and *non-problem gamblers* placed higher bets when they had to imagine that hypothetical money was provided by *experimenter* (M=2.56 and M=2.4, respectively) rather than when they had to imagine that hypothetical money was their own (M=2.36 and M=1.8, respectively). However, this difference was more accentuated for *non-problem gamblers* ($p<.000$) than for problem gamblers ($p<.05$). No difference emerged in the two games where the winning probabilities varied. The graphic n. 1 shows the three-way interaction *gambling status x money provenance x probability.*

Graphic 1: Means of bet choice in the three-way *gambling status x probability x money provenance* interaction.



When the ANCOVA model was performed introducing the BSSS and BIS-11 scores as covariates, the two-way interactions *gambling status* x *money provenance* and *probability x money provenance* were no longer significant ($p=.281$ and $p=.166$, respectively) as well as the three-way interaction *gambling status x money provenance x probability,* in which they were comprised (p=.14). Instead, two new two-way interactions emerged: *probability x condition,* $F_{4,287} = 2.587$; $p < .05$; p-η^2 =.035, and *probability x BIS-11 scores,* $F_{1,287} = 4.151$; $p < .05$; p-η^2 =.014.

The *probability x condition* interaction was examined through the analysis of simple effects with Bonferroni correction. Results showed that in the two games where the winning probabilities were *fixed*, in the *joy* (M=2.69) and *anger* (M=2.44) conditions, participants bet more than those in *sadness* (M=1.98) and *fear* (M=1.97) conditions, whereas no significant difference emerged compared with the participants in the control condition (M=2.33). Such effects also emerged in the two games where the winning probabilities *varied*, although the participants' bets in joy and sadness conditions did not significantly differ.

The *probability x BIS-11 scores* interaction, examined through parameter estimates, showed that the impulsiveness levels were directly proportional to bet wager in the two games where the winning probabilities were fixed (B =.001 and .009, in game 1 and 3, respectively) and inversely proportional in the two games where the winning probabilities varied (B = -.007 and -.008, in game 2 and 4, respectively).

- ***Mediation analyses***

To examine whether the effect of experimental conditions on bet choice would be mediated by skin conductance and heart rate, the SCRs and HR means related to a 5-seconds window immediately before the choice in the four tasks were extracted from participants' physiological tracks.

After that, eight different mediation analyses, four concerning the putative mediation of *SCR* on the bet choice for each game and the same for the HR putative mediation, were carried out. Mediation analyses were conducted with the PROCESS macro (Model 4) for SPSS (Hayes, 2013). For each analysis, the multicategorical independent variable, corresponding to the five experimental *conditions*, was coded as four dummy variables (Anger = 1; other conditions = 0 / Fear = 1; other conditions = 0 / Sadness = 1; other conditions = 0 / Joy = 1; other conditions = 0), with control condition as reference category. The dependent variable was the bet choice for the four games and each *physiological measure* was included as mediator. *Gambling status*, coded in a dummy variable (1 = problem gamblers; 0 = non-problem gamblers), was included as covariate rather than as a moderator since Process macro (as well as Mplus structural equation models) does not allow to carry out a moderated mediation analysis whereas the independent variable is multicategorical. Results did not show any incidence of *SCRs* or *HR* on the bet choice in none of the four games: so, no mediation was exerted by the two physiological arousal indices in the relationship between study conditions and bet choice.

The same results were obtained when the BSSS and BIS_11 scores were added as other covariates.

Discussion and conclusions

The present study investigated the incidence of induced positive and negative emotions, in problem and non-problem gamblers, on the choice of the bet amount in four gambling tasks where the winning probabilities and bet provenance were manipulated.

More specifically, the study aimed to examine whether experiencing positive or negative emotional states would match with modifications in physiological parameters, whether different induced emotions with the autobiographical recall technique would specifically affect the participants' choices, and whether such choices were mediated by the physiological arousal. Finally, the study aimed to identify potential differences between problem gamblers and non-problem gamblers and to investigate whether personality factors, such impulsivity and sensation-seeking affected the participants' responses. For this purpose, physiological indices of skin conductance (SC) and heart rate (HR) were recorded. Participants were assigned to one of five experimental conditions based on the induced emotion (anger, fear, sadness, joy, and control condition without induction) and the behavioral indices of how much they wanted to bet in each of the four games were collected.

The results of the analyses conducted on the self-reported emotional evaluations indicated that the experimental manipulation was successful for both participants' groups. Whereas in the control condition the intensity of the six self-assessed emotions did not vary, in the other four conditions (anger, fear, sadness, joy) the intensity of the induced emotion varied considerably after the induction procedure.

Regarding the variations of physiological indices, the results revealed a lower activation in problem gamblers compared to non-problem gamblers. As to the specific effects of the HR, only in *fear* and *joy* inductions it increased in both groups. In *anger* and *sadness* conditions, HR variations were observed only in *non-problem gamblers*: the induction of anger produced an increase in HR, whereas sadness caused a decrease. In the control condition, HR did not change in both groups.

The physiological modifications in *non-problem gamblers* are in line with the literature on emotional arousal: the induction by the autobiographical recall technique of *anger* (Prkachin et al., 1999; Neumann and Waldstein, 2001; Hamer et al., 2007), *fear* (Aue et al., 2007) and *joy* (Sinha et al., 1992; Neumann & Waldstein, 2001) was characterized by increased HR, while sadness with no cry entailed a decrease of HR (Britton et al., 2006; Gruber et al., 2008; Tsai et al., 2000).

As to SCLs, they increased with the induction of *anger*, *fear*, and *joy*, whereas they did not vary in *sadness* and in *control* conditions. However, although both groups showed an increase in SCL in the abovementioned conditions, such effect was higher in *non-problem gamblers* than in problem gamblers. In addition, SCLs did not vary in the two participants' groups in the control condition.

These results differ from those of the studies reporting higher physiological arousal in problem gamblers compared to non-problem gamblers (Leary and Dickerson, 1985; Blanchard et al., 2000) or no significant differences between the groups (Anderson and Brown, 1984; Griffiths, 1995; Coventry and Norman, 1997).

They suggest that problem gamblers are less activated on a physiological level even if they perceive a significant difference pre/post induction in self-reported emotional assessment. For example, although problem-gamblers reported higher subjective levels of anger after emotional induction, this did not correspond to their actual physiological activation, as unchanged heart rate showed.

Concerning the main goals of the study, i.e. examining whether the induction of different emotions caused dissimilar effects on participant's bet choice, the results are in line with the *Appraisal Tendency Framework* (Lerner & Keltner, 2000, 2001). Regardless of their gambling status, participants engaged in a riskier behavior after *joy* and *anger* inductions, whereas they were more cautious after *fear* induction; *sadness* induction did not seem to produce specific effects on decision behavior, since no difference emerged between sadness and control conditions. This finding is in line with the results of the study of Lerner and Keltner (2000), where inducing fear led participants to a lower risk-taking behavior, while anger had the opposite effect. Instead, differently from the predictions of AIM and MMH, according to which positive and negative emotions would have an opposite influence on risk-taking, the participants induced in a negative state, as anger, did not make choices different from the ones they made in a positive state, as joy. Indeed, in such conditions, participants made more sizeable bets as well as found in Stanton et al. (2014).

As expected, problem gamblers made higher bets than non-problem gamblers except for the joy condition where the bet amount of the two groups did not differ. An analogous result was found in the study of Hills et al. (2001), where no differences were found between regular and non-regular gamblers in happy and control conditions, whilst regular gamblers induced in a sad state played more than non-regular ones.

The results of the present study also showed that both problem gamblers and non-problem gamblers were more cautious when they were asked to imagine having to bet with their own money rather than when they had to suppose that bets would be made with the experimenter's money. Such effect, also observed in the control condition, showed that the participants were able to imagine in their mind the difference between their own money and non-personal money.

Participants bet more in the two games where the winning probabilities varied compared to the ones where probabilities were fixed. This effect was greater in problem gamblers than in non-problem gamblers. However, the preference for such type of games was not related to variations in the physiological parameters, contrarily to the findings of Studer et al. (2016) with a sample of healthy university students.

Bet wager in these two games was inversely proportional to the impulsiveness levels of participants, while it was directly proportional in the games with fixed winning probabilities. Such effect was probably due to the fact that, in the game where winning probability were fixed, participants had to be less careful doing the calculations. Therefore, the most impulsive participants preferred to bet more in these two games.

However, also in this study no relevant effects of personality traits emerged. In fact, the introduction of impulsiveness and sensation-seeking scores as covariates into the model revealed that they made non-significant some effects that were already quite weak. Besides, such effects were analogous but more accentuated in one term of the interaction than in the other.

The mediation models tested to investigate whether the effects of the induced emotional states on the bet choice in the four games were mediated by physiological factors showed that neither SCRs nor HR affected the participants’ choices. To the best of my knowledge, there are not studies that have examined the effect of physiological responses on dependent variables using them as mediators of the effect of the emotional activation. Although a comparison with the concerning literature cannot be carried out, these results suggest that the role of emotional arousal in decision-making should be further investigated.

Conclusions

The present research focused on the cognitive and emotional factors involved in decision-making related to problem gamblers and healthy individuals. The first two studies investigated the effects of two specific cognitive distortions - the illusion of control and the gambler's fallacy - on problem and non-problem gamblers, whereas the third study investigated the influence of some induced discrete emotions on decision-making of the two participants' groups.

To this end, a large group composed by 160 problem gamblers (recruited in the Gambling Addiction Services of Campania), without comorbidity, was compared with an analogous non-problem gamblers' group, whose participants were matched by age (from 18 to 68) and educational level (mainly high school, with low percentages of degree and primary middle school). The gambling activities reported by the problem gamblers were Sport betting (53%), VLT (Video Lottery Terminal) and Slot machines and (26%), Cards games (11%), and Lotto-Lottery-Scratchcard (10%). On the contrary, in the only Italian prevalence study (Barbaranelli, 2013) in which the gambling activities were reported, the most played games were (instant and traditional) lotteries. The prevalence studies of Bastiani et al. (2011) and Colasante et al. (2013) did not indicate the usual gambling games.

In the study on the illusion of control, it was examined whether previous outcomes of personal and random choices in a gambling task influenced the winning probability estimates (linked to personal or random choice of the next betting turn), the choice of the agent, and the bet amount. From this study emerged that both participants' groups showed both a tendency to *illusion of control* and a preference for *agency*. Indeed, all participants preferred to choose *personally* the slot colour on which to bet (index of *preference for agency)* and also tended to attribute *greater winning probabilities* to personal choice (index of *illusion of control*) than to the random one entrusted to another agent (the computer). Only in the experimental condition in which the number of wins and losses had be largely in favour of the computer, the participants tended to attribute similar winning probabilities to themselves and to pc. On the contrary, also when personal choices were mainly losing and the ones made by the computer were equally distributed in wins and losses, a misattribution of the winning probabilities in line with the illusion of control was found.

However, on the one hand people were influenced by the illusion of control on a *cognitive* level (the more participants overestimated their personal winning probabilities, the more they opted for personal choices) but, on the other hand, they were influenced by previous events on a *behavioural* level, i.e. when they had to bet. Indeed, compared to the control condition (where wins and losses were equally distributed between participants' choices and pc choices) they bet less in the two conditions in which their previous personal choices mainly resulted in losses.

The second study investigated the occurrence of the gambler's fallacy and its relationship with probability estimates of the next outcome and the bet amount in a gambling task. In literature the gambler's fallacy has been associated with the *representativeness heuristic* (Tversky & Kahneman, 1971; Kahneman, & Tversky, 1972; Rabin, 2002), the level of *controllability* of the events (Ayton & Fisher, 2004, Burns & Corpus, 2004), the *previous* winning or losing outcomes (Boynton, 2003), the implied *cognitive load* (Braga et al., 2013), and the degree of perceived intentionality exerted by the agent generating the runs (Caruso et al. 2010). To my knowledge, only Boynton (2003) checked the possible effect of the intrinsic characteristics of the stimulus, not finding any effect.

In the study presented in this thesis, two indexes of fallacy were used: a *cognitive* index (the probability estimate of occurrence of a given event) and a *behavioural* index (the choice of the slot on which to bet). Such a procedure, on the one hand, allowed to detect that these processes were independent; on the other hand, it allowed to discover that people's choices were based primarily on an *affective* process, that is, the preference for a particular outcome (i.e., the red slot). Indeed participants preferred to bet on a red slot both when previous series ended with (one or four) black slots and when it ended with one red slot. Only when the sequences ended with four red slots, participants reversed their preference in a choice in line with the gambler's fallacy, i.e. choosing a black slot. Furthermore, as it emerged from the moderated mediation analyses, *probability estimates did not influence that choice.* Such finding seems not casual, as the same result pattern was recently found in the study of Matarazzo et al. (2017) with a different decision-making task. In this study, in a card guessing game (high vs. low card), individuals preferred to bet mainly on high cards and reversed this tendency, choosing low cards (in line with the gambler's fallacy), only when the run of high-cards increased (4 high cards vs. 1 high card). On the contrary, when the sequences ended with low cards, people preferred to bet on high cards, independently of the run length.

On the whole, these findings seem to support the hypothesis according to which the *preference* for a given stimulus is an automatic and basic process acting on decision-making (Zajonc, 1980). Instead, the judgment heuristic would be a more complex process that in certain circumstances (e.g., in case of a long sequence) acts on decision-making, upstaging the influence of the affective heuristic.

These processes did not affect differentially the two participants' groups. The difference between the two groups was related to betting behaviour, as problem gamblers bet more than non-problem gamblers, and to *personality traits*, as problem gamblers showed *higher impulsivity and sensation-seeking levels* than non-problem gamblers. This latter result is in line with the studies showing a proneness to impulsiveness (Blaszczynski et al., 1997; Vitaro et al., 1999; Nower & Blaszczynski, 2006; Ledgerwwod et al., 2009) and to sensation seeking (Kuley and Jacobs, 1988; Powell et al. 1999; Gupta et al. 2006; Hodgins and Holub (2015) in problem gamblers. However, in the present studies these personality factors do not seem to have affected the participants' behaviour in a relevant way.

Overall, the two studies indicate that problem gamblers do not show a greater propensity to the two cognitive distortions compared to non-problem gamblers. So, these findings do not to corroborate the widely shared assumption that problem gamblers report more cognitive distortions, and to a greater extent, than non-problem gamblers (Davis et al., 2000; Griffiths, 1994; Lim et al. 2015; Ladouceur & Walker, 1996; Michalczuk et al. 2011; Miller & Currie, 2008; Myrseth et al. 2010; Nower et al., 2004; Petry, 2001; Romo et al., 2016).

However, to the best of my knowledge, so far only two studies have compared the extent of the two phenomena in problem gamblers and non-problem gamblers. Orgaz et al. (2013) investigated the occurrence of the illusion of control in 49 problem gamblers and 51 controls, with a contingency judgment task. They found that pathological gamblers

overestimated their control more than the control group, although the behaviour of the two groups in decision-making did not differ. Results from the study of Wilke et al. (2014), whose sample was composed by 92 experienced gamblers and 72 individuals with little gambling experience, found that, in line with the hot-hand fallacy, gamblers preferred to bet on the random sequence, which allowed to perceive more illusory patterns (positive recency effect) rather than on the sequence negatively autocorrelated. The control group did not show any preference for one or the other sequence.
It should be emphasised that the findings presented in this thesis do not prove that problem gamblers are not subject to the cognitive distortions but highlight that non-problem gamblers also seem to be prone to these distortions in a similar extent.

The third study has investigated the effect of four emotions (anger, fear, sadness and joy) on gambling-related decision-making. Starting from the Appraisal-tendency framework (ATF, Lerner and Keltner, 2000, 2001), the specific effect of discrete emotions on decision-making has been increasingly recognized. Nevertheless, only a few studies (Hills et al., 2001; Potenza et al., 2003; Mishra et al., 2010) have been interested in the effect of discrete emotions in gambling behaviour. To the best of my knowledge, this is the first study that investigates the effect of four emotions.

The results seem to corroborate Lerner and Keltner's hypothesis, as shown by the different effects on decision-making following the induction of the three negative emotions. In fact, *anger* induction caused different effects (more risky behavior) than those caused by *fear* induction (more prudent behavior), whereas *sadness* induction did not have effects different from those of the control condition (where no emotional induction was expected). Differently from the predictions of *Affect Infusion Model* (AIM, Forgas, 1995) and *Mood Maintenance Hypothesis* (MMH, Isen, 1978), according to which positive and negative emotions have opposite effects on decision-making, the effects of inducing a positive emotion (i.e., *joy*) did not differ from that of negatively-valenced emotions like *anger*. Additionally, the highest bets were found following the induction of these two emotions. Probably, the central dimensions (*certainty*, *control*, *responsibility*) of these emotions played a role. Especially anger, which attributes responsibility for negative events to others, is characterised by individual control and sense of certainty about what happened and, therefore, lower risk perception in new situations.

Also in this study, the observed effects were independent from gambling status: in fact, problem gamblers made more risky choices than non-problem gamblers, both as a result of the emotional induction and in the condition of control. The only exception was found following the *joy* induction, where the choices between the two groups did not differ.

This study also has investigated whether people's behaviour was influenced by physiological arousal and whether this putative influence differed between the two participants' groups. The results showed a lower physiological activation in problem gamblers than non-problem gamblers. In the latter group, the physiological variations due to emotional induction seem in line with the literature on emotional physiological activation through autobiographical recall (Neumann & Waldstein, 2001; Hamer et al., 2007; Aue et al., 2007). Such effects were not found in problem gamblers, as the unchanged physiological parameters (HR) following *anger* and *sadness* induction revealed. However, self-reported assessments of problem gamblers showed higher values of these emotions after the emotional induction. This incongruity is at least surprising as it concerns emotions that in literature are frequently associated with problem gambling. These results indicate that the association between these two emotions and the gambling behaviour should be investigated further. Problem gamblers also showed an increase in SCLs as a result of emotional induction that was lower than in non-problem gamblers. It seemed reasonable to expect that problem gamblers, which showed higher scores in the personality traits of impulsivity and sensation-seeking, would show more elevated physiological activation indices and that such indices would be associated with the proneness to bet. On the contrary, a major finding of this study is that problem gamblers seem to be motivated to bet independently from the previous emotional state and from their physiological activation. Here, it appears that the levels of physiological arousal are more an incidental component during the game situations than a factor leading people to assume riskier behaviour. In light of the different findings obtained in other studies, the relationship between gambling and physiological arousal also need to be further investigated. The results so far obtained did not allow to understand whether problem gamblers bet more in order to increase their arousal or, contrarily, to alleviate their excessive arousal. The present results do not let to decide between the two hypotheses but certainly do not support the latter.

One might think that the games presented in the third study, the experimental setting and the absence of monetary rewards would not precisely reproduce a gambling context and, consequently, were not sufficiently activating on a physiological level. However, it should be noted that problem gamblers scored less than non-problem gamblers on physiological indices following autobiographical recalls, a technique with high ecological validity. Moreover, even in a "non-excting setting" like the one we created, problem gamblers bet more than non problem gamblers.

Finally, as it has been pointed out previously, monetary rewards were deliberately excluded from the experimental setting for ethical and theoretical reasons. As some authors (Kühberger, 2001; Read, 2005) posit, the presence of economic incentives is not necessary to evaluate how people behave in hypothetical contexts. Furthermore, even when real money is involved, it may have a different subjective value for both problem gamblers and non-problem gamblers (Clark, 2014). As the results of this study revealed, the effect of bet provenance clearly shows how the participants were able to represent the differences between imagining to have a budget available for betting (in conformity with what happens in canonical procedures with monetary incentives) and imagining to have to bet their own money.

Appendix Study 1

Figure 1 - General Instructions

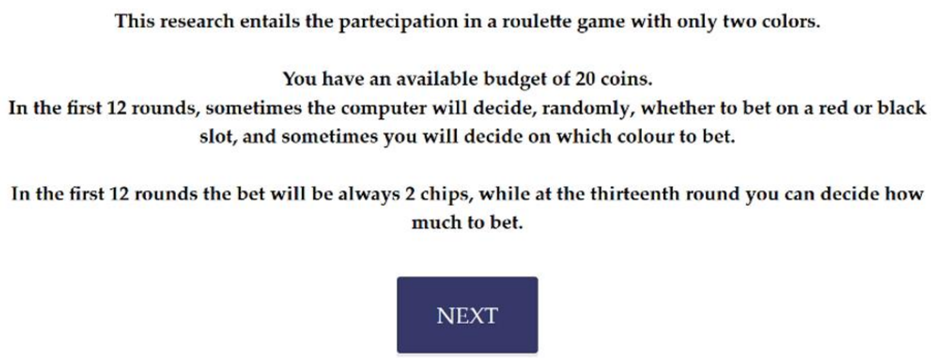


Figure 2 – Rounds: Personal or computer choice

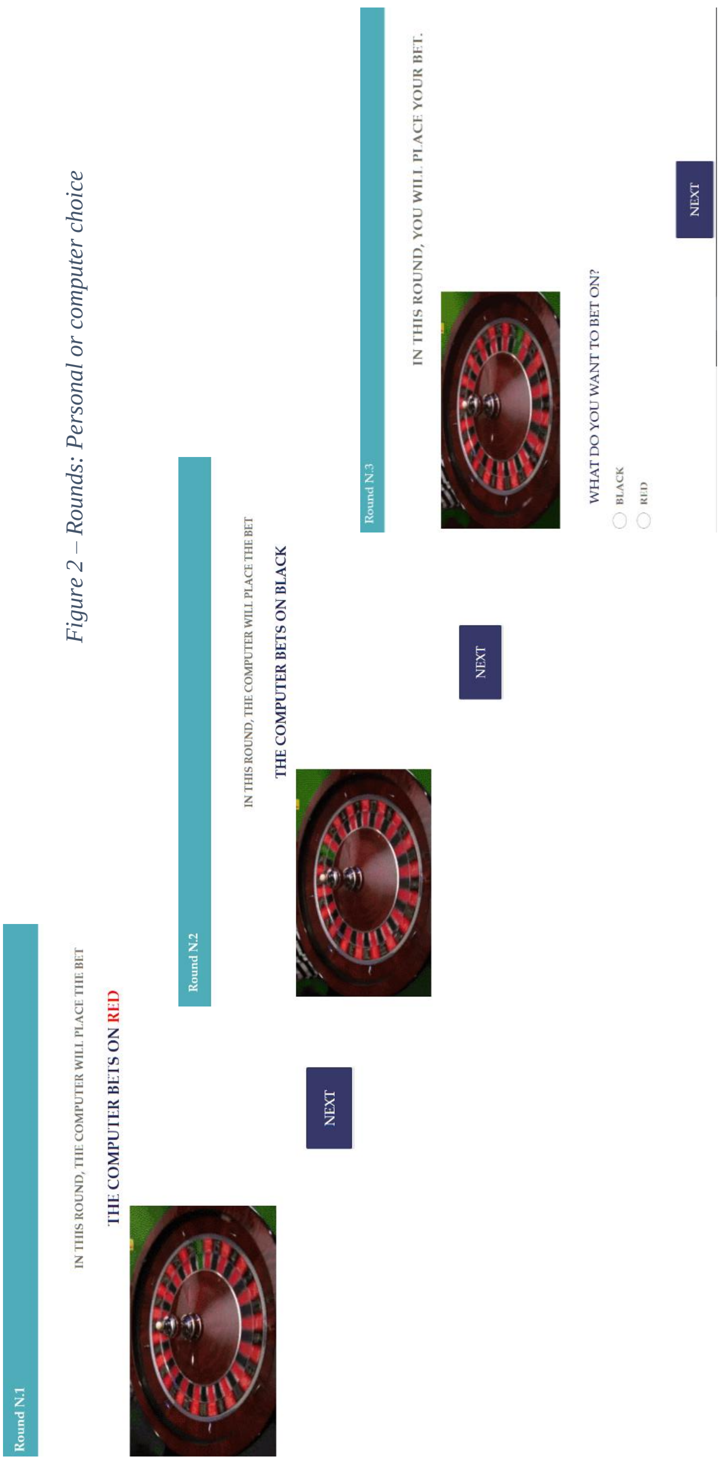


Figure 3 – Possible outcomes

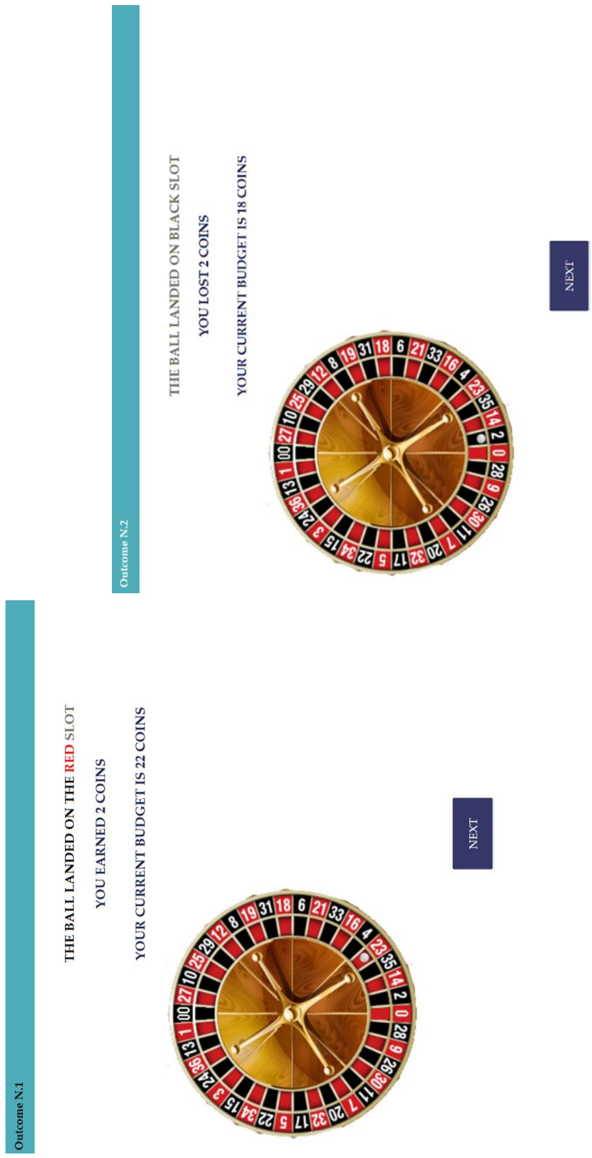


Figure 3 - Probability estimates questions

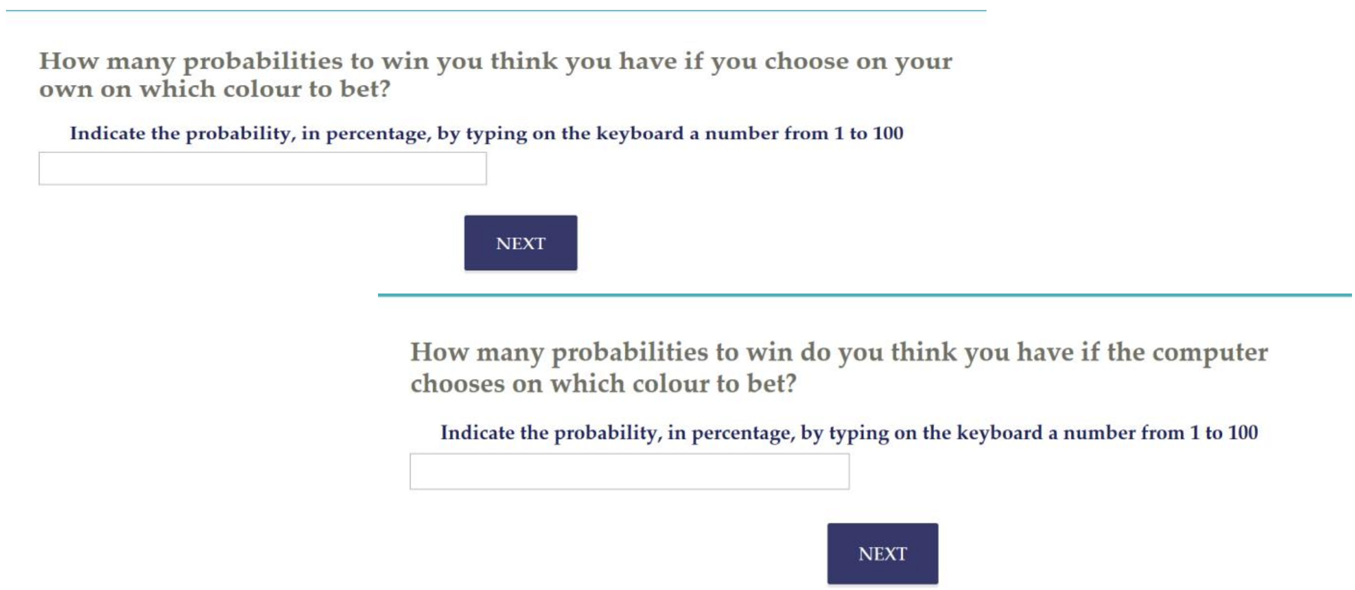


Figure 5 – Choice questions (in the two possible orders)

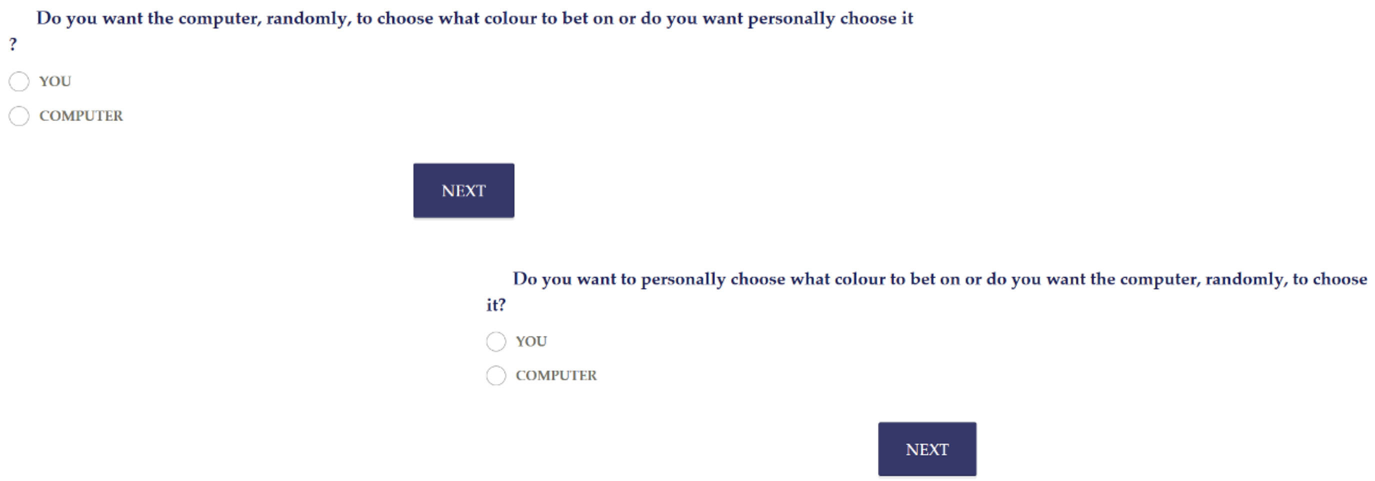
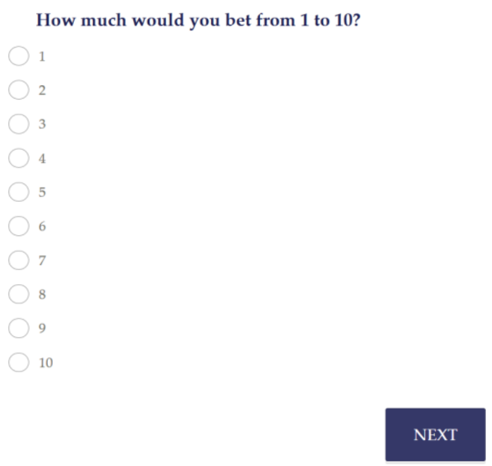


Figure 6 – Bet question



Appendix Study 2

Figure 1 – General instructions

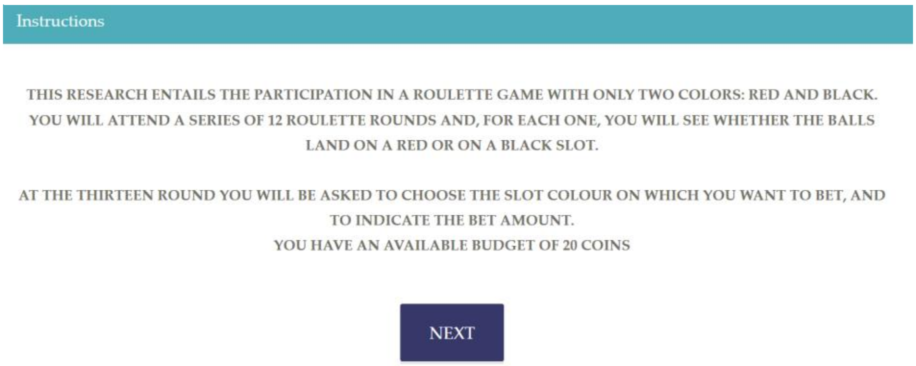


Figure 2 – Round

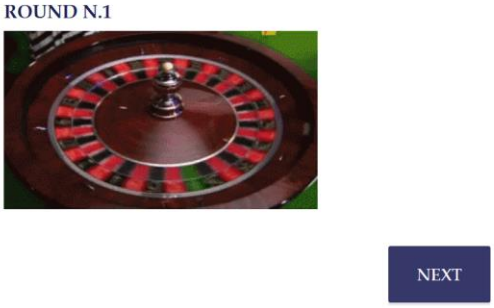


Figure 3 – Possible outcomes

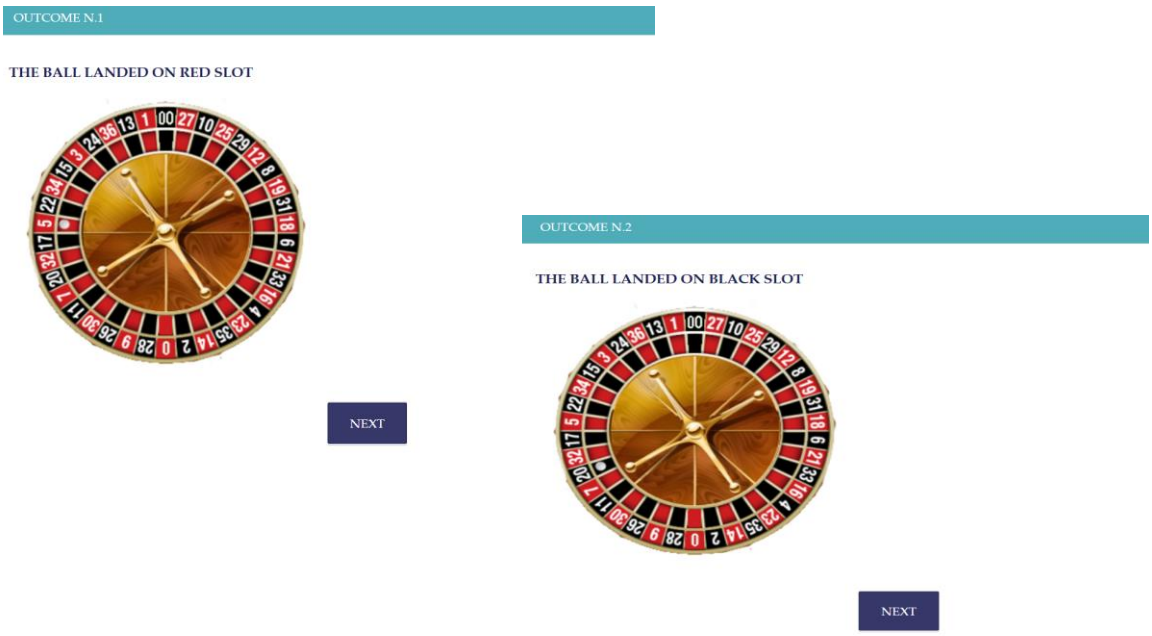


Figure 4 –Probability estimates questions

HOW MUCH DO YOU THINK IT IS LIKELY THAT THE BALL WILL LAND ON A BLACK SLOT?

Indicate the probability, in percentage, by typing on the keyboard a number from 1 to 100

NEXT

HOW MUCH DO YOU THINK IT IS LIKELY THAT THE BALL WILL LANDS ON A RED SLOT?

Indicate the probability, in percentage, by typing on the keyboard a number from 1 to 100

NEXT

Figure 5 – Choice question

SELECT RED OR BLACK TO INDICATE WHICH COLOUR YOU WANT TO BET ON

- RED
- BLACK

NEXT

Figure 5 – Bet question

YOUR AVAILABLE BUDGET IS 20 CHIPS. HOW MUCH WOULD YOU BET FROM 1 TO 10?

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10

NEXT

Appendix Study 3

Figure 1 -2: Game 1: General instructions and choice options

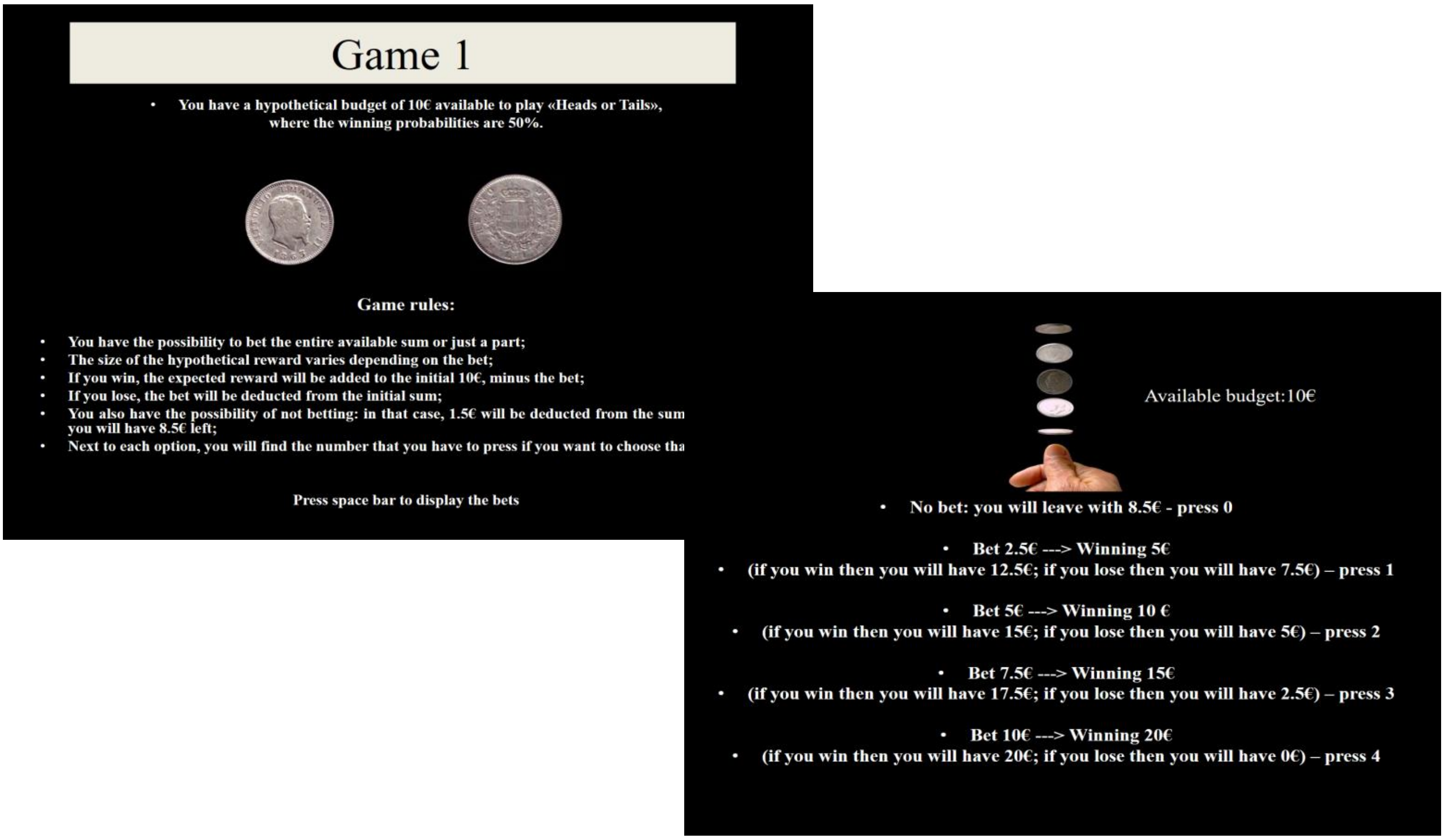


Figure 3 -4: Game 2: General instructions and choice options

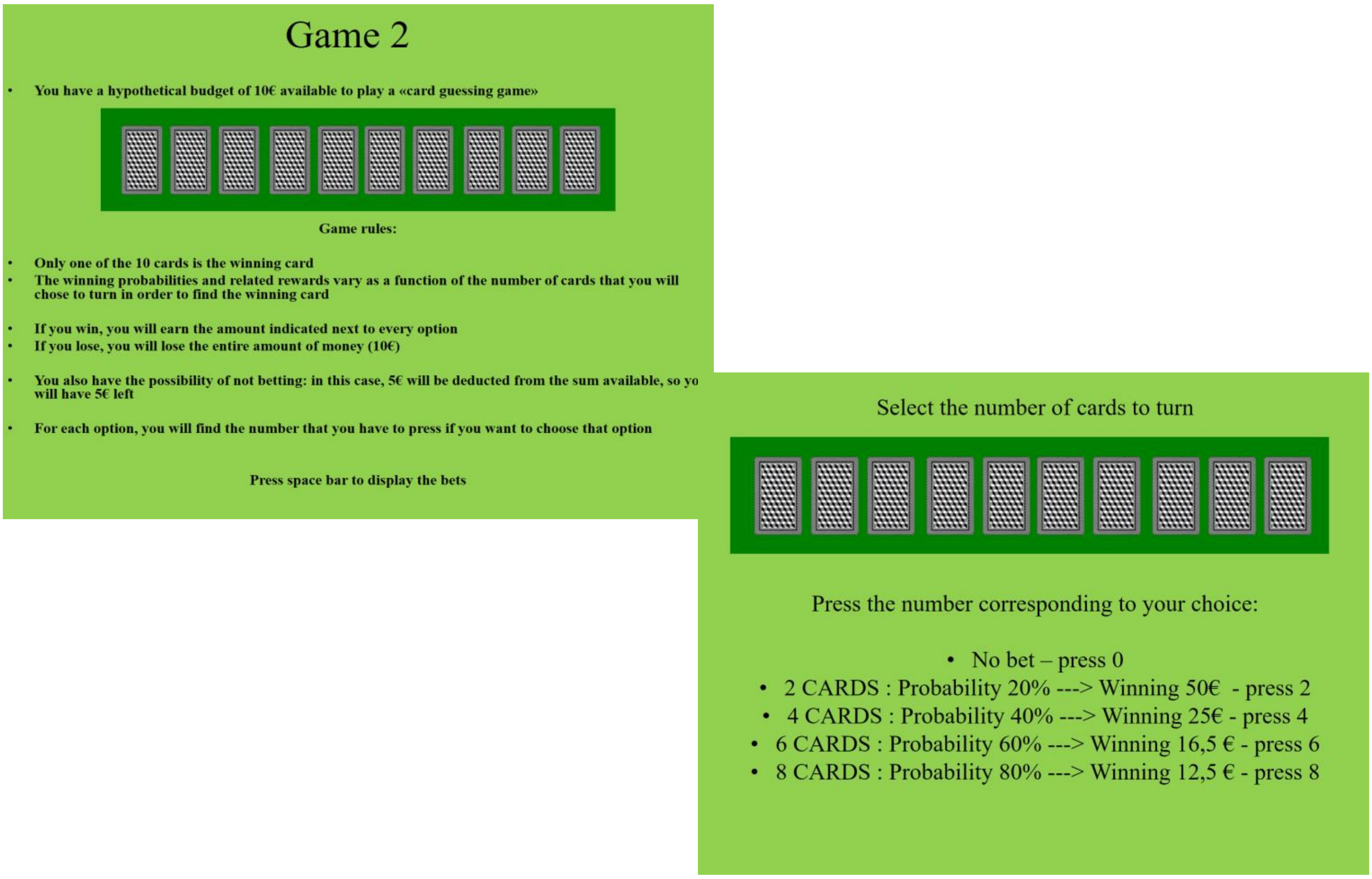


Figure 5-6: Game 3: General instructions and choice options

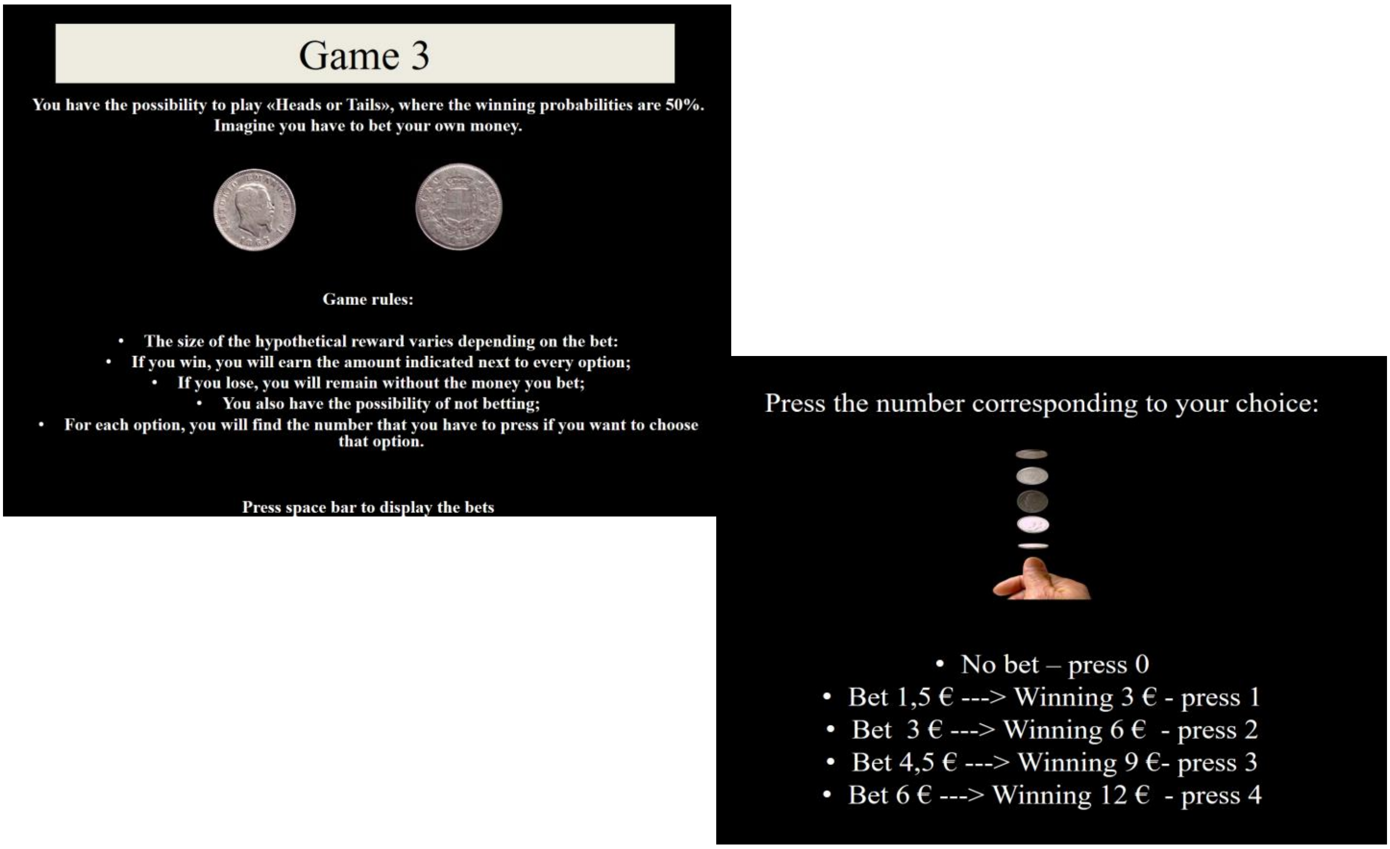
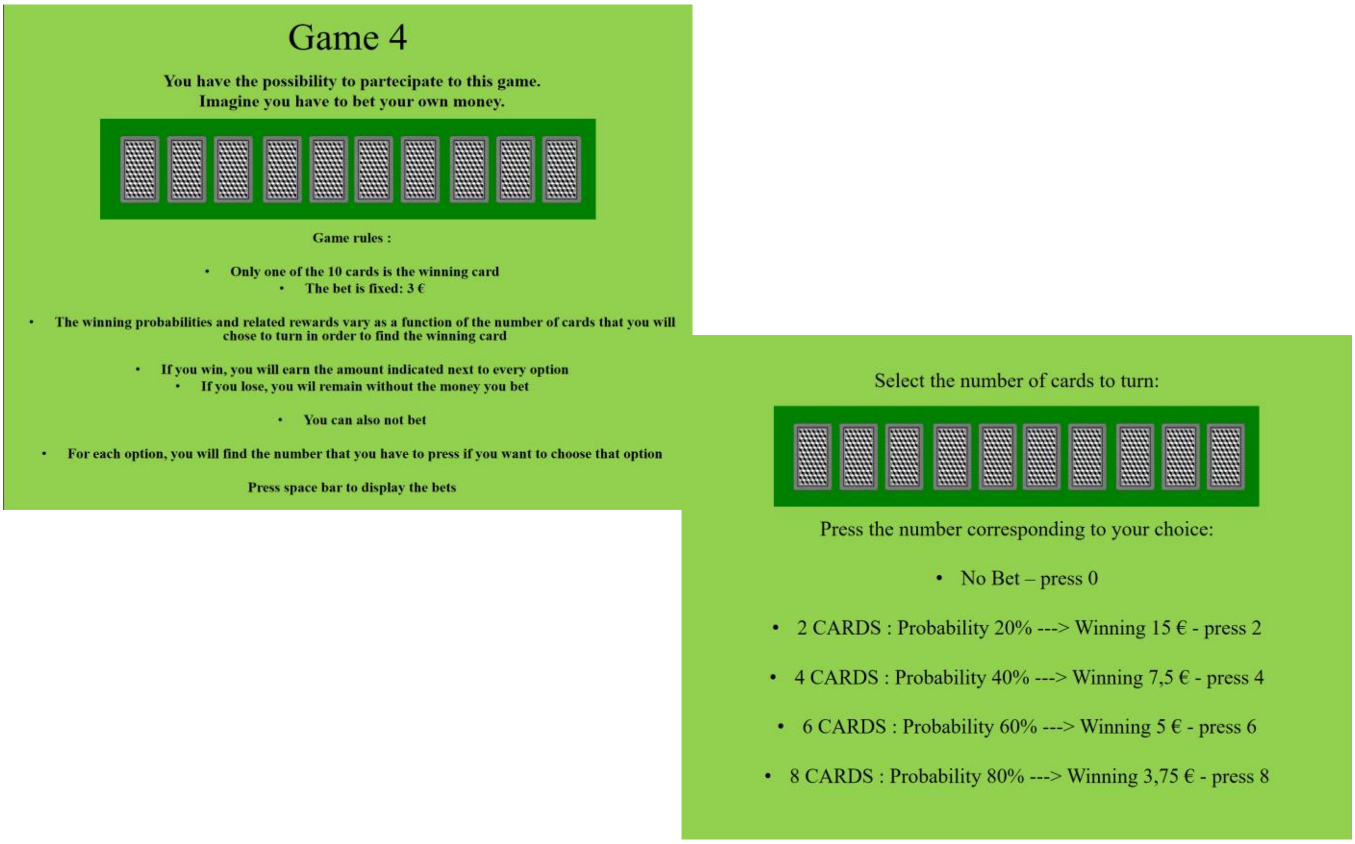


Figure 7-8: Game 4: General instructions and choice options



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