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Reduced risk-taking after prior losses in pathological gamblers under treatment and healthy control group but not in problem gamblers

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Corresponding Author:	Lucia Savadori, Ph.D. Universita degli Studi di Trento Trento, ITALY
Corresponding Author Secondary Information:	
Corresponding Author's Institution:	Universita degli Studi di Trento
Corresponding Author's Secondary Institution:	
First Author:	Nicolao Bonini
First Author Secondary Information:	
Order of Authors:	Nicolao Bonini
	Alessandro Grecucci
	Manuel Nicolè
	Lucia Savadori, Ph.D.
Order of Authors Secondary Information:	
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Lucia Savadori
Professor in Psychology
University of Trento

Jon E. Grant
Editor-in-Chief
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Trento, 6 July 2017

Dear Jon E. Grant,

Thank you for the opportunity to revise and resubmit manuscript titled "Reduced risk-taking after prior losses in pathological gamblers and healthy control group but not in problem gamblers" (#JOGS-D-17-00071) for the Journal of Gambling Studies. Here is the list of responses.

1. The reviewer asked that we spend a bit more time in discussing the apparent anomaly (i.e., that the pathological gamblers are still very different in their attitudes - e.g. impulsiveness - to the other groups, but not in the behavioral measure of risk-taking after prior losses). We added these clarifications, both in the introduction and in the discussion sections, describing the reason why we expect to find no differences between pathological gamblers and controls in the behavioral risk-taking measure.
2. As suggested by the reviewer, we included the specification “under treatment” in the title, which now reads: “Reduced risk-taking after prior losses in pathological gamblers under treatment and healthy control group but not in problem gamblers”.
3. We rephrased the sentence p.6 "… previous studies missed to find any …" into “The fact that previous studies did not find any behavioral difference….” as asked.
4. The sentence “Another 20 were excluded because they did not meet eligible criteria (having no physical, psychiatric or neurological problems at the time of the study)” was disambiguated as follows: “Another 20 were excluded because they did not meet eligible criteria (i.e., they had physical, psychiatric or neurological problems at the time of the study).”
5. Following the suggestion of the reviewer, at page 20 “lower the average line” was changed into “lower than the average line”.
6. We added the phrase “One possibility is that we were just very unlucky in the sample that we have ended up with.” after the sentence: “The finding that all three groups show the same risk-taking tendency when no prior losses …..” to acknowledge the reviewer concern.

Thank you for your consideration.

Sincerely,

Lucia Savadori

Reduced risk-taking after prior losses in pathological gamblers under treatment and healthy control group but not in problem gamblers

Nicolao Bonini, Alessandro Grecucci, Manuel Nicolè and Lucia Savadori

University of Trento

Author Note

Nicolao Bonini, Department of Economics and Management, University of Trento.

Alessandro Grecucci, Department of Psychology and Cognitive Sciences, University of Trento.

Manuel Nicolè, Department of Economics and Management, University of Trento.

Lucia Savadori, Department of Economics and Management, University of Trento.

Correspondence concerning this article should be addressed to either Nicolao Bonini, Dipartimento di Economia e Management, Via Inama 5, 38122, Trento (Italy) Contact: nicolao.bonini@unitn.it, or Lucia Savadori, Dipartimento di Economia e Management, Via Inama 5, 38122, Trento (Italy), Contanct: lucia.savadori@unitn.it.

Compliance with Ethical Standards

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Conflict of Interest: Nicolao Bonini declares that he has no conflict of interest. Alessandro Grecucci declares that he has no conflict of interest. Manuel Nicolè declares that he has no conflict of interest. Lucia Savadori declares that she has no conflict of interest.

Ethical Approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Reduced risk-taking after prior losses in pathological gamblers under treatment and healthy control group but not in problem gamblers

Abstract

A group of pathological gamblers and a group of problem gamblers (i.e., gamblers at risk of becoming pathological) were compared to healthy controls on their risk-taking propensity after prior losses. Each participant played both the Balloon Analogue Risk Taking task (BART) and a modified version of the same task, where individuals face five repeated predetermined early losses at the onset of the game. No significant difference in risk-taking was found between groups on the standard BART task, while significant differences emerged when comparing behaviors in the two tasks: both pathological gamblers and controls reduced their risk-taking tendency after prior losses in the modified BART compared to the standard BART, whereas problem gamblers showed no reduction in risk-taking after prior losses. We interpret these results as a sign of a reduced sensitivity to negative feedback in problem gamblers which might contribute to explain their loss-chasing tendency.

Keywords: risk-taking, prior losses, pathological gambling, loss-chasing, negative feedback, resilience.

Reduced risk-taking after prior losses in pathological gamblers under treatment and healthy control group but not in problem gamblers

How is risk-taking in pathological and problem gamblers affected by prior losses? Will pathological gamblers and problem gamblers be affected by prior losses at the same degree as healthy controls? It is well-known that "chasing" one's losses, that is continuing to gamble, often with increasing bet size, to recover from losses is common among problem gamblers (Dickerson, Hinchy, & Fabre, 1987; Lesieur, 1979; O'Connor & Dickerson, 2003). For example, 64% of problem gamblers in a large random household survey admitted they regularly chased their losses (Schellinck & Schrans, 1998) and more than 75% of problem gamblers in another survey reported chasing losses (Toce-Gerstein, Gerstein, & Volberg, 2003). However, experimental evidence of loss-chasing in gamblers is scant (see for exceptions, Brevers, He, Xue, & Bechara, 2017; Linnet, RØjskjÆr, Nygaard, & Maher, 2006). Here we present a study examining risk-taking after prior losses in three groups: pathological gamblers, problem gamblers, and healthy controls.

Risk taking after prior losses

When an individual has just experienced a loss, he/she is generally more prone to take a risky gamble, as compared to when gains preceded the choice pattern (Bibby, 2016; Brevers et al., 2017; Losecaat Vermeer, Boksem, & Sanfey, 2014; Vermeer & Sanfey, 2015; Xue et al., 2010; Xue, Lu, Levin, & Bechara, 2011; for exceptions see Thaler & Johnson, 1990; Weber & Zuchel, study 2, 2005). This tendency is not explained by the normative economic theory that prescribes that decision makers should only care about incremental outcomes (i.e., future gains and losses) and not about past gains and losses. Whereas, it is usually explained by the convex shape of the loss function in the Prospect Theory which predicts that people will generally be risk seeking in the domain of losses (for simple prospects). The reason is that the curvature of the function makes the disutility of losing $50 (sure loss) greater than the disutility of losing $100 by fifty percent (risky gamble) and the decision-maker opts for the risky, less damaging gamble. This notion has been repeatedly demonstrated in empirical work (eg., Hershey & Schoemaker, 1980).

However, in these 'prospect theory' type of studies, subjects are usually provided with the descriptive information about the objective probabilities of winning and losing (i.e., 50% of winning 100$). In our view, this opens the possibility to question the generalization of these results to those decisions that do not entail an explicitly stated probability. As noted by some researchers (Franken, Georgieva, Muris, & Dijksterhuis, 2006; Rosi, Cavallini, Gamboz, & Russo, 2016), real world decisions are more likely associated to uncertain or ambiguous outcomes and not to clearly defined outcome probabilities.

In an attempt to generalize to real world decisions, a couple of studies examining choices after prior losses (Franken et al., 2006; Rosi et al., 2016) employed the Iowa Gambling Task (IGT; Bechara, Damasio, Damasio, & Anderson, 1994), a laboratory task where probabilities have to be learnt by trial and error by the decision maker while playing the task itself. Franken and colleagues (2006) found that subjects who experienced a prior monetary loss made more risky choice behaviors on the subsequent IGT task (i.e., more disadvantageous/unsafe choices) than subjects who experienced a prior gain, thus in line with previous studies employing explicit probabilities. However, significant differences between the gain and the loss groups were confined to Blocks 2 and 3 out of a total of 5 blocks in the IGT. On the contrary, Rosi and colleagues (2016) in a subsequent replication of the study found that decision makers who experienced prior monetary gains or prior monetary losses did not display significant differences in safe/risky choices in subsequently performed IGT. Summarizing, when risk-taking after prior losses was measured in a task that did not employ description of probabilities, less support for an increase in risk-taking after prior losses was observed.

In order to further investigate risk-taking after prior losses under uncertainty we employed the Balloon Analogue Risk Taking task (BART; Lejuez et al., 2002). In the BART task individuals are required to make repeated choices (inflate a balloon) where risk levels (the probability of the balloon exploding) escalate as a result of one's previous decisions which is considered one of the main characteristics of real-world risky behaviors (Figner, Mackinlay, Wilkening, & Weber, 2009; Leigh, 1999; Lejuez et al., 2002; Pleskac, Wallsten, Wang, & Lejuez, 2008) and is missing in the IGT task.

Gamblers and the BART

Gamblers are diagnosed as pathological when their condition assessed through a formal instrument (e.g. SOGS; Lesieur & Blume, 1987) exceeds a certain threshold (e.g., a score of 5 in the SOGS); whereas they are considered problem gamblers when their score is high but it does not exceed the threshold (e.g., SOGS score from 3 to 4). Problem~~atic~~ gamblers are at risk of becoming pathological. Both pathological and problem gamblers are recognized as being impulsive individuals (for reviews see Grant, Potenza, Weinstein, & Gorelick, 2010; MacKillop et al., 2011; Robbins & Clark, 2015). The BART is also a well-known, behaviorally incentivized, task to measure impulsivity within the risk-taking domain (Lauriola, Panno, Levin, & Lejuez, 2014). Moreover, the BART is, by definition, a gambling task. Curiously, however, few published studies to date found any behavioral difference between pathological gamblers and controls on the BART. Although growing evidence is accumulating on decisional bias in gamblers (Giorgetta et al., 2014; Grecucci et al., 2014). Out of four studies comparing gamblers vs. healthy controls on the BART task, only two found the predicted difference, while the other two found no difference between groups. More precisely, one study on an adult population found that pathological gamblers were about twice as likely to pump the balloon compared to a matched sample of healthy controls (Ciccarelli, Griffiths, Nigro, & Cosenza, 2017), confirming a previous study on adolescent population by the same authors comparing two adolescent groups, non-problem gamblers versus problem gamblers (Cosenza, Griffiths, Nigro, & Ciccarelli, 2017). Whereas pathological gamblers with past substance abuse disorder pumped more than pathological gamblers without substance use disorder, although both groups were similar to the control group, whose number of pumps was between the two (Ledgerwood, Alessi, Phoenix, & Petry, 2009). Likewise, pathological gamblers recruited within a community of drug-abstinent substance-dependent individuals were not significantly different in average number of adjusted pumps when compared to controls and to drug-abstinent substance-dependent individuals who were not pathological gamblers (Krmpotich et al., 2015).

One possible explanation for these inconsistent results might be that the only study~~ies~~ that found a difference between ~~groups involved~~ pathological gamblers and controls (Ciccarelli et al., 2017) involved individuals who were not undergoing any treatment, or were at the early stage of treatment, while individuals with past substance use disorders were likely under some treatment at the time of the study (however the authors do not provide such information) and this might explain the lack of differences. Indeed, the most common technique to determine if a player is pathological or not, is to administer the SOGS questionnaire (Lesieur & Blume, 1987). However, the SOGS asks to “indicate which of the following types of gambling you have done in your lifetime”, and not at the present time. For this reason, some players who have been

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pathological in the past but who are no longer so in the present, are classified as pathological. Pathological gamblers are usually recruited inside, or with the help of, treatment facilities, as we did in the present study. The chances are high, therefore, that these gamblers are under some sort of treatment at the time of the study. The same applies to other pathological figures, such as drug addicts who are often no longer using drugs at the time of the study but they are under methadone or other forms of treatment. Gamblers undergoing treatment are, with no doubt, to be considered "pathological", but they may also have undergone a profound change in their behaviors (indeed, this is what is hoped). It is then possible to expect that if they are tested on exactly those behaviors that are the subject of treatment (gambling), as in the present study, the positive effect of the treatment clearly emerges, making pathological gamblers in fact indistinguishable from control individuals. In other studies that investigated pathological gamblers, this may not have occurred simply because the observed variable was not a behavioral measure (on which the cure had effect) but a dispositional variable (e.g., trait impulsivity), which needs a much longer treatment to be modified (if ever). We therefore expect no differences between the group of pathological gamblers and control individuals in the risk-taking behavior (BART) but we do expect differences in dispositional traits, such as impulsivity. Previous studies, indeed, found that compared to controls, pathological gamblers, especially those in the later stages of therapy for gambling disorders, were more loss averse (i.e., the tendency to weight losses more than gains in accepting gambles) whereas their impulsivity traits were still significantly higher than those of the controls: a result that was explained as evidence of successful therapy (Giorgetta et al., 2014).

Risk-taking after prior losses in gamblers

Compared to controls, pathological gamblers playing the IGT task showed a lower number of advantageous choice sequences (i.e., five consecutive "good" cards) and a higher number of disadvantageous choice sequences (i.e., five consecutive "bad" cards) which was coded by the authors as an instance of increased "chasing" behavior in gamblers (Linnet et al., 2006). The study by (Linnet et al. (, 2006)is study, however, did not directly manipulate prior outcomes (losing vs. winning). When prior wins and losses were experimentally manipulated, frequent poker players (SOGS score from 2 to more than 5) and controls were not different in their behaviors in the IGT task (Brevers et al., 2017). However, compared to controls, poker players exhibited lower brain activations in the posterior areas of the superior frontal gyrus when elaborating on a decision after losing, as compared to after winning, suggesting that deciding after a loss might have induced lower action preparation for the upcoming decision, potentially coding for participants' low anticipation to recover from their previous loss. Conversely, compared to controls, they exhibited higher brain activation when elaborating on a decision after winning the previous gamble, suggesting that prior win outcomes might be especially relevant while pondering the next gambling strategy. Simplifying, poker players showed an hyposensitivity to losses and an hypersensitivity to gains, as reflected in their brain activations.

The fact that previous studies missed did notto find any behavioral difference between gamblers and non-gamblers in risk-taking after prior losses is puzzling, given the evidence that gamblers frequently engage in a loss-chasing tendency. We argue that the reason why gamblers and non-gamblers failed to show any behavioral difference is in part due to the use of an appropriate task that mimics real-world behaviors. For this reason we developed a modified version of the BART (Lejuez et al., 2002) (hereafter called "Unlucky BART" or simply "U-BART") where gamblers face early repeated losses (i.e. the early explosion of the balloon after few pumps) in the first five trials, and normal losses in the following 25 trials. We then compared the individuals' risk-taking tendency in the U-BART with that observed in the same individual in a standard version of the BART.

We hypothesized that, differently from previous studies using explicit probabilities (e.g. Xue, Lu, Levin, & Bechara, 2010), the BART task would elicit a behavioral reaction in healthy subjects such that prior losses would be experienced as a punishment and/or a negative affective label attached to the stimuli which would reduce the chances of repeating the behavior. Typical learning theories of operant conditioning (Skinner, 1984; Thorndike, 1898) indeed predict that when the individual performs a behavior (pumping the balloon, representing increased risk-taking) that is followed by an aversive stimulus (monetary loss, representing a punishment) the individual decreases the frequency of such behavior (reduction of pumping, representing decreased risk-taking). A similar prediction can be made using the affect heuristic (Slovic, Finucane, Peters, & MacGregor, 2007) or the somatic marker hypothesis (Damasio, 1994), both of which assume that the individual learns through trials and errors whether a specific stimulus (e.g. a deck of cards, a slot-machine, a balloon) is good or bad, and then adapts to reduce the chances of incurring a negative outcome (e.g. decreases the number of picks from bad decks, decreases the number of plays from the bad slot-machine, decreases the number of pumps).

We therefore expect to observe that healthy controls reduce their risk-taking after prior losses in the U-BART compared to the BART. However, we also expect that, compared to controls, problem gamblers would be less affected by the experience of an early sequence of prior losses, thus showing a reduced sensitivity to punishment as it was found in regular poker players (Brevers et al., 2017). Furthermore, in accordance with previous studies (Giorgetta et al., 2014), we do not expect to observe any different behavior between healthy controls and pathological gamblers under treatment. That is to say that we do not expect pathological gamblers in our study to show evidence of loss-chasing behavior given that they are under specific treatment for pathological gambling.

Method

Participants

Forty adults (23 Males; Mean Age = 49.74) diagnosed with pathological gambling in line with DSM 5 (American Psychiatric Association, 2013) and ICD 10 (World Health Organization, 1993) criteria and a SOGS score superior to 5, 40 problem gamblers (23 Males; Mean Age = 49.1) diagnosed with problematic gambling in line with SOGS criteria (SOGS score from 3 to 4) and 40 healthy controls (20 Males; Mean Age = 51.8) participated in the study.

Procedure

Pathological gamblers were recruited through the local Rehabilitation Center for Drug Addicts, and several local non-profit organizations that help people with gambling addictions. Pathological gamblers had previously been diagnosed with DSM IV (APA, 1994), and all were under treatment. All pathological gamblers who decided to adhere were administered the South Oaks Gambling Screen (SOGS; Lesieur & Blume, 1987). Following the authors' classification code, individuals with a score above 5 were coded as pathological gamblers. Then they were administered the rest of the tasks.

Control participants and problem gamblers were recruited through a dedicated web site, FaceBook, Twitter, leafletting and newspaper and radio ads. Leaflets were distributed outside the city's main gambling establishments. Posters publicizing the study were placed in the University facilities and public libraries. The ads asked for individuals who "gambled frequently" or "gambled recreationally" to participate in a study to explore factors associated with gambling.

All individuals who responded were administered the South Oaks Gambling Screen (SOGS; Lesieur & Blume, 1987). Following the authors' classification code, individuals with a score of 0 to 2 were assigned to the healthy control group and those with a score of 3 to 4 were assigned to the problem gamblers group. Participants were then contacted a second time to complete the study. Of the original 317 participants who voluntarily adhered to the study, 86 were excluded because they refused to take part to the next part of the study or did not respond to the invitation to participate in the next phase. Another 20 were excluded because they did not meet eligible criteria (i.e., they hadhaving no physical, psychiatric or neurological problems at the time of the study). The remaining 211 participants were divided in two groups (problem gamblers, healthy controls) and were matched by age and sex to the pathological gamblers group. This matching procedure excluded the last 131 participants from the study and left us with the final sample of 40 participants for the healthy group and 40 for the problem gambler group.

Assessments and Measures

Participants in the problem gambling group and the healthy controls group were first administered the SOGS questionnaire (Lesieur & Blume, 1987) and those who met the criteria for eligibility were called to take part in the second part of the study. At the second show up, they were administered the rest of the instruments, whereas pathological gamblers were administered all instruments at the same time.

All participants were administered the following measurement: the Yale Brown Obsessive Compulsive Scale for Pathological Gambling (PG-YBOCS; Pallanti, DeCaria, Grant, Urpe, & Hollander, 2005), the Barratt Impulsiveness Scale (BIS-11; Patton, Stanford, & Barratt, 1995), the UPPS-P Impulsive Behavior Scale (UPPS-P; Lynam, Smith, Whiteside, & Cyders, 2006), the Balloon Analogue Risk Task (BART; Lejuez et al., 2002) and the modified version of the BART (U-BART). Another psychological task unrelated with the present study was performed by each patient. Questionnaires and interviews were presented after the behavioral tasks, in random order. All participants were tested individually in a quiet room. Average completion time was about 1 hour.

Gambling Severity. Gambling severity was assessed through the SOGS (Lesieur & Blume, 1987) questionnaire. The questionnaire comprises 16 items measuring gambling severity. This is the measure that is most often used in research studies to identify pathological gambling (Walker & Dickerson, 1996). The SOGS was developed in a clinical setting, but is often used in general population studies. It includes gambling involvement, behavioral signs of gambling problems, and consequences of gambling problems. The SOGS was found to have satisfactory reliability with coefficient alphas of .69 and .86 in the general population and gambling treatment samples, respectively (Stinchfield, 2002). However, while the SOGS has demonstrated good classification accuracy in the gambling treatment sample, it has had poorer accuracy in the general population sample with a tendency to overestimate the number of pathological gamblers in the general population, as compared to DSM-IV diagnostic criteria.

Obsessive compulsive symptoms. The Obsessive-compulsive symptoms were assessed with the Yale Brown Obsessive Compulsive Scale for Pathological Gambling (PG-YBOCS; Pallanti, DeCaria, Grant, Urpe, & Hollander, 2005), which measures the severity of the obsessive compulsive gambling symptoms. The PG-YBOCS scale was modified from the Yale-Brown Obsessive-Compulsive Scale (YBOCS; Goodman et al., 1989). The PG-YBOCS consists of ten questions that measure the severity of pathological gambling within a set period of time (i.e., the past one/two week(s)). The first five questions assess urges and thoughts associated with pathological gambling, whereas the last five questions assess the behavioral component of the disorder. Both sets of questions focus on time occupied by gambling, interference due to gambling, distress associated with gambling, resistance against gambling, and degree of control over gambling. Time, interference, distress, resistance, and control are the items that correspond to DSM-IV criteria for pathological gambling (APA, 1994). Scores of 0 through 4 are assigned according to the severity of the response (0 = least severe response, 4 = most severe response). Each set of questions is summed separately as well as together for a total score.

Impulsiveness. Impulsiveness was assessed by means of two instruments: the Barratt Impulsiveness Scale (BIS-11; Patton, Stanford, & Barratt, 1995) and the UPPS-P Impulsive Behavior Scale (UPPS-P; Lynam et al., 2006).

The BIS-11 scale (Patton et al., 1995) was designed to assess the personality trait of impulsiveness. It is an improvement over previous versions of the BIS, including Barratt's (1959) original measure. The scale is made up of 30 items using 4-point ratings (1 = never/rarely, 2 = occasionally, 3 = often, 4 = almost always/always) and includes 3 sub-scales: Attentional Impulsiveness (assesses task-focus, intrusive thoughts, and racing thoughts), Motor Impulsiveness (assesses tendency to act on the spur of the moment and consistency of lifestyle) and Non-planning Impulsiveness (assesses careful thinking and planning and enjoyment of challenging mental tasks). Sample items are “I am restless at the theater or lectures (Attentional Impulsiveness)”, “I buy things on impulse” (Motor Impulsiveness) and “I plan tasks carefully” (Non-planning Impulsiveness).

The UPPS-P Impulsive Behavior Scale (UPPS-P; Lynam et al., 2006) is a revised version of the UPPS Impulsive Behavior scale (Whiteside & Lynam, 2001) designed to measure Positive Urgency in addition to the four factors assessed in the original version of the scale. It comprises

59 items using a four point Likert-type scale. It includes 5 sub-scales: Premeditation (lack of), Urgency (negative), Sensation Seeking, Perseverance (lack of) and Positive Urgency. Sample items include "I am a cautious person" (premeditation), "When I feel rejected, I will often say things that I later regret" (negative urgency), "I would enjoy water skiing" (sensation seeking), "Once I get going on something I hate to stop" (perseverance), "When I am very happy, I can't seem to stop myself from doing things that can have bad consequences" (positive urgency). Higher scores indicate more impulsive behavior.

Risk-taking. Individual risk-taking preferences were assessed through the Balloon Analogue Risk Task (BART; Lejuez et al., 2002) and a modified version of the same task ideated to measure risk-taking after prior losses, the Unlucky BART (U-BART). The BART was designed to assess risk preferences through choices made in a scenario. Participants inflate a computerized balloon. The goal is to inflate the balloon to its maximum inflation, but not more. Each "successful" pump is worth 10 cents. If the balloon is inflated past its individual explosion point, it pops and the participant loses all money earned on that balloon. There are 30 trials (30 balloons). Each balloon starts with a probability of 1/128 to explode (unknown to the participant). Each time a pump is made, this probability is updated accordingly (1/127, 1/126). Hence, the probability of exploding increases as the amount of money collected increases. In every moment the participant can stop pumping and collect the money earned in that balloon and pass to the next balloon. When all 30 balloon have been played the individual is remunerated with the total amount of money collected through the 30 balloons (excluding those exploded). This task has been extensively used to measure both risk-taking preferences in normal populations (Benjamin & Robbins, 2007; Cazzell, Li, Lin, Patel, & Liu, 2012; Lejuez et al., 2002) but also in clinical or at-risk populations (Hunt, Hopko, Bare, Lejuez, & Robinson, 2005;

Lejuez et al., 2003, 2007). The BART has shown acceptable test-retest reliability across days ($r = +.77$, $p < .001$) and therefore performance on the task on a single occasion is likely to be representative of an individual's performance on other occasions (White, Lejuez, & de Wit, 2008).

To best meet the aims of this study, a modified version of the BART was ideated. The BART and the U-BART were counterbalanced across individuals. This new version shares all the same features with the standard BART task, except that the probability of explosion for the first five balloons was manipulated. While in the standard BART the probability of explosion for each balloon starts at 1/128 and this probability stays the same for all the 30 balloons, in the modified U-BART the first five balloons exploded respectively at the 1°, 2°, 3°, 2°, and 1° pumps. The balloons from 6 to 30 instead had the same 1/128 probability of explosion as in the standard BART. The U-BART simulates the experience of repeatedly losing for five consecutive plays, like it happens when you repeatedly loose at a slot machine.

For ethical reasons pathological gamblers were not remunerated for the participation in the study but they were told that the amount of money they collected in the behavioral tasks would be donated to the local Rehabilitation Center for Drug Addicts. Problem gamblers and healthy controls were remunerated according to the money won in the behavioral task.

Data analysis

Data analysis was computed using IBM SPSS Statistics release 24.0. The initial data analysis assessed the differences between the three groups (pathological gamblers, problem gamblers and healthy controls) on demographic, clinical and personality variables using parametric or non-parametric statistics, as appropriate. One participant of the pathological gamblers group whose cognitive impairment was discovered after the data were collected, was excluded from the data analyses. The alpha significance level was set at 0.05. The subsequent analyses addressed the differences between the three groups on the average number of adjusted (unexploded balloons) pumps both in the standard version of the BART and in the modified U-BART. To make comparisons possible between the BART and the U-BART, the average number of adjusted pumps in trials 1 to 5 was excluded from the analyses in both tasks, because they were artificially manipulated by the experimenter in the U-BART. Analyses were completed only on the remaining trials from 6 to 30. To outline the temporal sequence of choices we analyzed the average number of adjusted pumps separating the time period in initial trials (from trial 6 to 10), interim trials (from trial 11 to 20) and final trials (from trial 21 to 30). This was not necessary, but we felt it gave a better idea of the resilience behavior of individuals after repeated losses.

We first computed a mixed analysis of variance (ANOVA) (3 x 3 x 2) with 'Group' (healthy controls vs. problem gamblers vs. pathological gamblers) as the between-participants independent variable and the average number of adjusted pumps in the BART in the three time periods ('Time': trials from 6 to 10 vs. trial from 11 to 20 vs. trials from 21 to 30) and in the two tasks ('Task': Standard BART vs. U-BART) as the two within-participants factors. To better outline the differences among the three groups we also ran a series of univariate ANOVA with 'Group' (healthy controls vs. problem gamblers vs. pathological gamblers) as the independent variable and the average number of adjusted pumps in the standard BART and in the U-BART as dependent variables. In order to specifically compare individual behavior in the BART and in the U-BART we also ran three pairwise t-tests comparing the overall number of adjusted pumps in the standard BART and in the U–BART, separately for each group. Demographic characteristics and personality traits were also separately entered as a covariate to the mixed AVOVA models to search for moderating effects. Zero-order correlations were calculated to examine the relationship between demographic characteristics, gambling severity, personality traits and behavioral measures of risk-taking.

Results

Group demographic and personality differences

Demographic data and differences on the personality traits are shown in Table 1. Sex and age did not differ between the three groups. In contrast, all other personality traits, did show differences between the groups. All three groups were different in the SOGS score, which was lowest for the healthy controls' group and highest for the pathological gamblers' group. Similarly, the measure of obsessive compulsive gambling (PG-YBOCS) showed highest scores for pathological gamblers and lowest for healthy controls, with all three groups significantly different from each other. Pathological gamblers were also more impulsive (BIS-11) than the other two groups, especially in the motor and non-planning subscales. Also problem gamblers were more impulsive than healthy controls on the BIS-11, especially in the motor subscale. The Impulsive Behavior Scale (UPPS) showed a similar pattern. Pathological gamblers were consistently more impulsive than the other two groups on every subscale, but problem gamblers also showed higher impulsive traits compared to healthy controls on the urgency subscale.

Risk taking

The mixed ANOVA analysis on the average number of adjusted pumps revealed a main effect for type of Task [$F(1,222) = 27.99$, $p = .0001$; $\eta_p^2 = .20$; see Figure 1]. The average number of adjusted pumps was lower in the U-BART than in the standard BART, showing evidence of reduced risk-taking after prior losses. Also, the analysis revealed a main effect for Time

[F(2,222) = 35.74, p = .0001; η_p^2 = .24]. Tests of within-subjects contrasts revealed that all three time blocks differed from each other significantly (p < .05): The number of pumps increased gradually from trials 6 to 30. However, this effect of Time interacted with the type of Task [F(2,222) = 12.06, p = .0001; η_p^2 = .10] showing that the increase in the number of pumps from trials 6 to 30 was steeper in the U-BART than in the standard BART, which shows instances of recovering (resilience) from the prior loss experience. Tests of within-subjects contrasts revealed that the average number of adjusted pumps were different between all three blocks between the two type of Tasks (all p <.05). The analysis also revealed only a marginal main effect for type of Group [F(2,111) = 2.48, p = .09; η_p^2 = 0.04;]. Post hoc tests showed that the pathological gamblers group made the least number of pumps (considering both BART and U-BART jointly) compared to the other two groups, but this difference did not reach significance at p = 0.05. Nor did Group significantly interact with any other factor (F < 1.70).

Further analyses of the Group factor were conducted separately for the two types of Tasks. Univariate ANOVA's with 'Group' as between subject factor revealed no group differences in the standard BART task (F = 1.48) , but significant group differences in the U-BART [F(2,114) = 3.67, p = .028; η_p^2 = .06]. Post-hoc tests revealed that the pathological gamblers group under treatment on average pumped an inferior number of times compared to the problem gamblers group (p < .05) in the U- BART while the healthy controls were in between the two other groups but were not significantly different from them.

Notably, pairwise t-tests showed that both the healthy controls and the pathological gamblers reduced risk-taking in the U-BART compared to the BART [t(39) = 4.46, p = .0001; t(37) = 3.73, p = .001] whereas the group of Problem Gamblers did not [t(36) = 1.19, p > .05].

Correlations and Individual differences

Bivariate correlations between age, gambling severity, personality traits and behavioral measures of risk-taking in the three groups showed some significant associations (see Table 2). Not surprisingly, the average number of adjusted pumps in the standard BART was positively associated with the average number of adjusted pumps in the modified U-BART in all three groups. This confirms the good test-retest reliability of the instrument. The two measures of impulsiveness (BIS-11 and UPPS) correlated with each other in all three samples, endorsing the fact that they both measure the same construct. Interestingly, but not surprisingly, impulsivity as measured by the UPPS instrument was positively associated with obsessive-compulsive symptoms (PG-YBOCS) only in problem gamblers, suggesting that their gambling problems might have an obsessive-compulsive origin. As expected, pathological gamblers with more severe gambling dependence, as measured by the SOGS, also showed higher impulsivity (BIS-11) and more severe obsessive-compulsive symptoms (PG-YBOCS), confirming the link between pathological gambling, obsessive-compulsive disorder and impulsive personality. In our sample of problem gamblers, older adults had more severe gambling symptoms, which might reflect an increase in problem gambling that rises with age, or a greater gambling habit due to more money availability in older subjects. No significant correlations were found between impulsivity and risk-taking measured with the BART and the U-BART in neither group. Curiously, the modified U-BART was positively associated with age in healthy subjects, which might indicate that older adults recover more quickly from prior losses (pump more) than younger adults.

We investigated a possible moderation effect of individual differences such as gender, age and personality traits on risk-taking in the two BART tasks. First, we separately entered gender and age as a covariate to the mixed AVOVA model reported earlier. There was no significant effect of gender or any significant interactions with other factors in the model and the introduction of gender as covariate did not change the pattern of significant effects. We then repeated the same procedure with age. There was no significant effect of age in the ANOVA model but age interacted with type of Task, [$F(1,110) = 4.00$, $p = .048$, $\eta_p^2 = .04$]: age was negatively associated with the average number of adjusted pumps in the standard BART (r = -.088, *n.s.*) but it was positively associated with the number of adjusted pumps in the modified U-BART (r = .044, *n.s.*). Risk-taking in our sample seemed to decrease in older adults, but an opposite trend was registered in the U-BART, which might signify that older adults recover more quickly from prior losses. Secondly, in order to investigate the possibility that the differences observed in the ANOVA were due to differences between the groups on the personality traits, we separately entered PG-YBOCS, BIS-11, UPPS scores as covariates to the mixed AVOVA model reported earlier. Introducing the BIS-11 score in the mixed ANOVA made all the effects of Tasks, Time and Task* Time disappear ($F < 1.7$) but no new effects emerged except an interaction between BIS-11 and Time [$F(2,220) = 3.43$, $p = .034$, $\eta_p^2 = .03$]. This could signify that individuals' impulsivity was in part responsible for the observed differences between the tasks (BART vs. U-BART) and between the trials. Seemingly, introducing the UPPS score as a covariate made all the effects disappear except for the Task * Time, which was still significant (at $p < .05$) but no main effect of UPPS or interaction emerged. Conversely, there was no significant effect of PG-YBOCS score on the model or any significant interactions with other factors in the model.

Discussion

In this study we examined whether problem gamblers, pathological gamblers and healthy control change their risk-taking preferences after experiencing a sequence of repetitive losses. To investigate this we experimentally induced a sequence of five repetitive negative outcomes and observed participants' subsequent risk-taking behavior compared to an identical task where no negative feedback was provided. We found that the three groups were not significantly different in their risk-taking when no prior loss was manipulated. However, after experiencing repetitive losses (i.e., an early explosion of the first five balloons), all groups, except problem gamblers, showed a cautious behavior, pumping with less enthusiasm in the subsequent trials, thus showing a reduced risk-taking. As shown in Figure 1 (Panel A), all groups reduced their risk-taking tendency after experiencing prior losses, but only the control group and the pathological gamblers group reached significance. In Panel B the degree of recovery is shown. Most of the groups recovered quite quickly from the unlucky circumstance (the early exploding of the first five balloons), except for the pathological gambling group, who had a slower recovery. Even after numerous trials, the average number of pumps of the pathological gamblers group stayed significantly lower than the average line of the problem gamblers group. On the other hand, the problem gamblers group was the least affected by the "bad luck" manipulation and quickly recovered, in line with a loss-chasing tendency. These results could be explained in two ways. On one hand, the data could signify a reduced capacity of resilience after a disaster by the pathological gamblers group. On the other, it could testify an inadequate sensitivity to losses by the problem gamblers group. Both could be true. Several studies with problem gamblers have found abnormalities in the reward systems of these individuals. For example, problem gambling was found to be related to response perseveration and reduced reward and punishment sensitivity as indicated by hypo-activation of the ventrolateral prefrontal cortex when money was both gained and lost (de Ruiter et al., 2009). And this is consistent with previous research showing that frequent and problem gamblers exhibit lowered brain reactivity to monetary feedback (Lole, Gonsalvez, & Barry, 2015). Therefore the hypothesis that problem gamblers are hyposensitive to punishments and /or hypersensitive to rewards (myopic reward seeking) has to be taken as a probable explanation for our findings that problem gamblers are less reactive to prior losses.

Alternatively, a reduced reactivity to rewards could also signify a reduced ability to adapt and learn from experience which could explain the lower pace of recovery after losses observed in our pathological gamblers group. Pathological gamblers (recruited from addiction treatment services) showed a reduction in the sensitivity of the reward system, and a reduction of ventral striatal and ventromedial prefrontal activation was negatively correlated with gambling severity (Reuter et al., 2005). Similarly, substance-dependent individuals with gambling problems showed less brain activity in ventral medial frontal, right frontopolar, and superior frontal cortex during decision-making in the IGT compared to controls (Tanabe et al., 2007). Reductions in brain activity during decision-making may reflect impaired working memory and stimulus reward valuation, which could explain our findings that pathological gamblers under treatment are slow in recovering after prior losses.

The finding that all three groups show the same risk-taking tendency when no prior losses were experienced ~~contradicts~~ is inconsistent with the study of Ciccarelli et al. (2017) ~~previous studies~~ where it was found that pathological gamblers pumped on average more than healthy controls on the BART task, showing an increased risk-taking tendency and with a study showing an analogous pattern in adolescent problem gamblers (Cosenza et al., 2017). ~~Our results are in~~

contradiction with these studies since Differently from these studies, we do not find any significant difference between groups on the BART, not even between problem gamblers and healthy controls. This is puzzling considering that the BART is a gambling task. However, our results are consistent with a couple of other studies that seem to find no difference on the BART between pathological gamblers and healthy controls (Krmpotich et al., 2015; Ledgerwood et al., 2009) . One possibility is that we were just very unlucky in the sample that we have ended up with. AnotherOne more explanation for the lack of difference is that our group of pathological gamblers was undergoing treatment. This might have altered their natural response and may explain in part their slower degree of recovery. We have previously mentioned that a gambler may be still categorized as pathological, but may have reduced his gambling behavior following treatment. However, the treatment should not have altered variables that are not behavioral, such as dispositional personality traits. That's why we expected to find no differences between the pathological group and the control group in their behavior during the risk-taking game. Confirming this interpretation, pathological gamblers showed significantly higher scores on all the dispositional variables (e.g., impulsivity) compared to the control group but did not show any difference on the behavioral measures.

As regards problem gamblers, no previousonly one study has shown differences on the BART between problem gamblers and controls but this was conducted on adolescents (Cosenza et al., 2017). Adult Pproblem gamblers are experienced and sophisticated players and probably were not sufficiently emotionally engaged by the BART task thus reducing their risk-taking behavior in the experiment. On the contrary, for a healthy control that is not familiar with gambling the BART task might be emotionally engaging and increase the risk-taking behavior. Future studies could use tasks more similar to real gambling tasks played by problem gamblers to find differences between the two groups or more abstract and basic measures of risk-taking such as lotteries à la Holt and Laury (2002).

The finding that healthy controls and pathological gamblers, despite being significantly different in impulsivity, showed reduced risk-taking after losses is definitely a new finding compared to previous studies showing the opposite pattern (Bibby, 2016; Brevers et al., 2017; Losecaat Vermeer et al., 2014; Vermeer & Sanfey, 2015; Xue et al., 2010, 2011). The difference, however, was expected. In previous tasks participants had to choose between gambles where outcomes and probability were explicitly stated. We instead employed a risk-taking task that resembles real-world risk-taking. Learning theorists (Skinner, 1984; Thorndike, 1898) would not be surprised by this result and would explain it as a change in behavior following negative punishment: a certain reinforcing stimulus (the balloon that pumps and money increases) is removed (explodes) after a particular behavior is exhibited (pumping), resulting in the behavior happening less often in the future (pumping a fewer number of times). Furthermore, in the BART task, differently from standard lottery-type tasks, the subject is required to perform a motor behavior (actively pump a virtual balloon), not simply to choose between two lotteries expressed in written language. This could be a crucial point of difference in respect to previous tasks and could have induced a conditioned response. Moreover, in the BART task, chances of explosion are learned through playing, thus making this task very similar to real gambling behaviors. A similar explanation could be proposed following the somatic marker hypothesis (Damasio, 1994) and the affect heuristic model (Slovic et al., 2007): the balloon that explodes after few pumps, repeatedly for five trials, signals to the amygdala that the balloon is “bad” and negative affect is rapidly attached to it inducing in the participant a higher risk perception which the participant naturally transforms in a reduced risk-taking behavior. This negative somatic marker is gradually reduced in intensity as the participant experiences the absence of the early explosion (punishment) in the subsequent 25 trials regains. Therefore, an operant conditioning and affect heuristic can easily explain our results.

Finally, the fact that a cautious, loss-sensitive behavior was observed in our study employing an “ecological task” increases the chances that our findings can be generalized to real-world gambling behaviors. The loss-insensitive behavior registered only in the problem gambler group represents a relevant finding that can explain why the group behaves in a loss-chasing way. Reduced sensitivity to punishment and increased sensitivity to reward may both be responsible for the conduct observed in problem gamblers in our study, but we collected empirical evidence only of the first instance. Future studies should address the second instance, for example, by manipulating rewards rather than punishments (i.e., by inducing prior repetitive winnings in the BART).

The result that pathological gamblers and healthy controls reacted similarly to the repetitive series of five bad-luck events during gambling is explained by the fact that pathological gamblers were under treatment. The same was observed in other studies (Giorgetta et al., 2012, 2014). However, pathological gamblers under treatment tended to overreact to the bad event, compared to problem gamblers, that is, they reduced their risk-taking tendency much more than problem gamblers. We could interpret this result as an instance of the effect of successful therapy by the pathological group. However, a slower recovery, we think, may also be related to a lower resilience ability, i.e., the ability to cope with change, and in this case, to recover from a disaster, as discussed earlier. Further studies should shed more light on this potential negative side effect of treatment provided to pathological gamblers.

Conclusion

In the current study we showed that experiencing prior losses reduces subsequent risk-taking in individuals. Individuals' risk-taking behavior (i.e., pumping the balloon) was sensibly reduced when it was followed by an artificially induced negative repetitive feedback (i.e., loss of accumulated earnings) for five consecutive trials. This result highlights the importance of reconsidering operant conditioning theories as plausible explanations for observed risk-taking after outcome feedback. These theories, indeed, assume that the evaluation of received punishments typically informs us as to whether we should either continue or adapt our current behavioral strategy. In the current study individuals adapted their behavior by reducing momentarily the target behavior. The same predictions could be made assuming a somatic marker hypotheses and/or an affect heuristic reasoning.

Moreover, we demonstrated that problem gamblers do not react to the punishment in the same way as healthy controls and pathological gamblers under treatment. Problem gamblers behaved as if they were hyposensitive to the sequence of repetitive negative feedback (losses): their behavior was not reduced as a consequence of negative feedback, contrary to what was observed in healthy controls. This might be an instance of the tendency of problem gamblers to "chase" losses, instead than trying to avoid them. Pathological gamblers instead behaved similarly to healthy controls, possibly due to their treatment which is directly addressed at avoiding risk-taking in gambling. More importantly, these results were observed in a task that features most of the characteristics of real-world decision making, increasing the possibility that we can generalize them to real behaviors.

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Table 1. Descriptive statistics and test of differences between healthy controls, problem gamblers and pathological gamblers (standard deviation in parenthesis).

	Healthy Controls (n = 40)	Problem Gamblers (n = 40)	Pathological Gamblers (n = 39)	Test (χ^2 or *F*)	Post-hoc (Tukey)*
Age, *M* (SD)	51.85 (7.42)	49.15 (11.89)	49.74 (10.99)	F (2,118) = 0.76, n.s.	
Gender: men % (*n*)	50 (20)	57.5 (23)	56.4 (22)	χ2 (2) = 0.53, n.s.	
SOGS	0.05 (0.22)	3.37 (0.49)	11.41 (3.33)	F(2,118) = 360.14, p = .0001	1 < 2 < 3
PG-YBOCS	0.37 (1.35)	6.27 (6.13)	17.85 (8.43)	F(2,118) = 85.18, p = .0001	1 < 2 < 3
Urges and thoughts	0.17 (0.81)	3.27 (3.06)	9.15 (4.45)	F(2,118) = 83.04, p = .0001	1 < 2 < 3
Behavioral component	0.2 (0.68)	3.00 (3.22)	8.69 (4.22)	F(2,118 = 77.90, p = .0001	1 < 2 < 3
BIS-11	58.27 (9.29)	64.97 (7.50)	69.79 (11.04)	F(2,118) = 15.06, p .0001	1 < 2, 3
Attentional Impulsiveness	15.00 (3.11)	16.42 (2.60)	16.85 (3.51)	F(2,118) = 3.88, p = .023	1 < 3
Motor Impulsiveness	19.10 (3.66)	22.53 (3.81)	23.64 (4.64)	F(2,118) = 13.519, p = .0001	1 < 2, 3
Non-planning Impulsiveness	24.17 (4.69)	26.02 (3.96)	29.30 (4.93)	F(2,118) = 12.88, p = .0001	1, 2 < 3
UPPS-P	103.62 (15.65)	127.25 (23.29)	131.59 (22.43)	F(2,118) = 20.96, p = .0001	1 < 2, 3
Negative Urgency	23.85 (5.49)	29.53 (7.19)	32.41 (7.30)	F(2,118) = 16.70, p = .0001	1 < 2, 3
Premeditation	17.50 (4.45)	18.57 (5.31)	21.31 (4.97)	F(2,118) = 6.25, p = .003	1, 2 < 3
Perseverance	16.85 (4.02)	17.7 (4.66)	19.64 (4.60)	F(2,118) = 4.093, p = .019	1 < 3
Sensation Seeking	23.97 (6.93)	30.07 (8.18)	27.35 (6.86)	F(2,118) = 6,899, p = .001	1 < 3
Positive Urgency	21.45 (4.77)	31.38 (9.46)	30.87 (8.96)	F(2,118) = 19.46, p = .0001	1 < 2, 3
BART	32.83 (16.84)	33.02 (23.39)	26.26 (18.58)	F(2,115) = 1.48, n.s.	
U-BART	25.91 (17.08)	30.15 (17.39)	19.34 (18.58)	F(2,116) = 3.673, p = .028	3 < 2

* 1 = Healthy Control, 2 = Problem Gamblers, 3 = Pathological gamblers

Table 2. Bivariate correlations between demographic variables, the personality traits and behavioral outcomes in the three groups

Healthy Controls
(n = 40)

	1	2	3	4	5	6
1. Age						
2. SOGS	.15					
3. PG-YBOCS	-.01	-.06				
4. BIS-11	.10	.06	.25			
5. UPPS-P	-.09	.18	.27	.52**		
6. BART	.26	-.12	-.11	.24	.26	
7. U-BART	.44***	-.08	-.25	.07	.04	.83***

Problem Gamblers
(n = 40)

	1	2	3	4	5	6
1. Age						
2. SOGS	.35*					
3. PG-YBOCS	.08	.22				
4. BIS-11	-.03	.01	.15			
5. UPPS-P	.02	.10	.41**	.34*		
6. BART	-.28	-.09	.02	.09	-.10	
7. U-BART	-.09	.00	.28	.04	-.02	.79***

Pathological Gamblers
(n = 39)

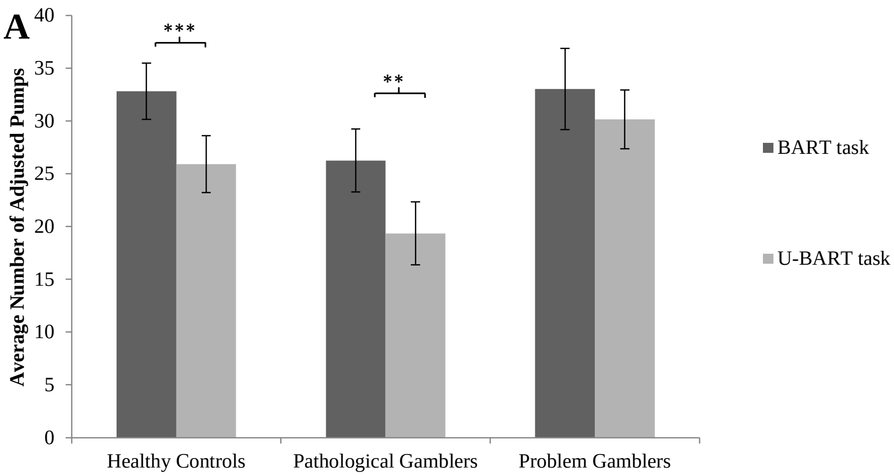
	1	2	3	4	5	6
1. Age						
2. SOGS	-.30					
3. PG-YBOCS	-.09	.35*				
4. BIS-11	-.31	.33*	.19			
5. UPPS-P	-.30	.28	.18	.72***		
6. BART	-.07	.22	.26	.09	.09	
7. U-BART	-.04	.06	.10	.19	.14	.86***

* = p < .05, ** = p < .01, *** = p < .001

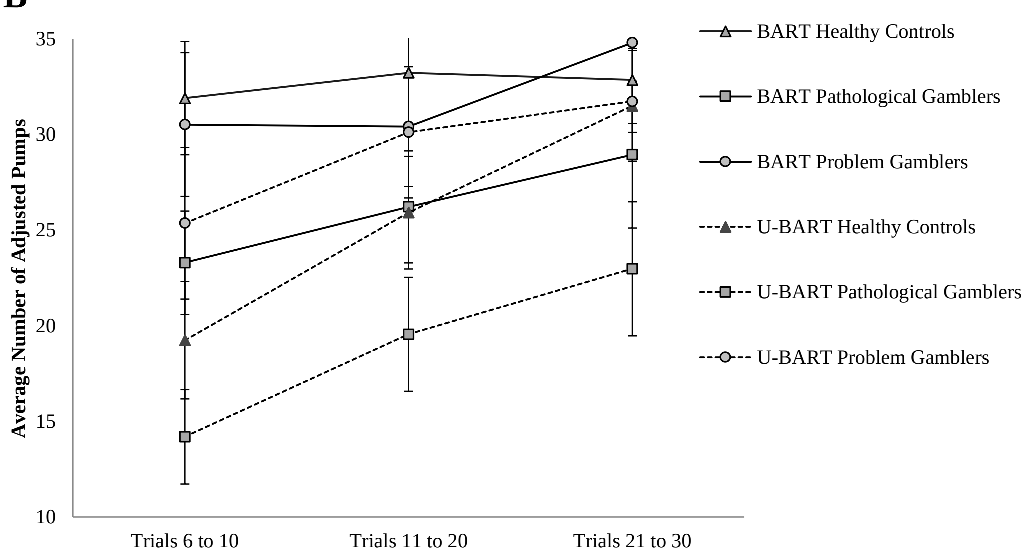
Figure Captions

Figure 1. Graphic display of the average number of adjusted pumps (the total pumps of the balloon that did not explode) for each group in the two tasks (A) and the average number of adjusted pumps for each group and time period (B). Error bars indicate SEM.

A


40
35
30
25
20
15
10
5
0
Average Number of Adjusted Pumps
***
**
Healthy Controls
Pathological Gamblers
Problem Gamblers
BART task
U-BART task

B


35
30
25
20
15
10
Average Number of Adjusted Pumps
Trials 6 to 10
Trials 11 to 20
Trials 21 to 30
BART Healthy Controls
BART Pathological Gamblers
BART Problem Gamblers
U-BART Healthy Controls
U-BART Pathological Gamblers
U-BART Problem Gamblers