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Luck, come here! Automatic approach tendencies toward gambling cues in moderate- to high-risk gamblers

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ABSTRACT

Background and aims Similar to substance addictions, reward-related cognitive motivational processes, such as selective attention and positive memory biases, have been found in disordered gambling. Despite findings that individuals with substance use problems are biased to approach substance-related cues automatically, no study has yet focused on automatic approach tendencies for motivationally salient gambling cues in problem gamblers. We tested if moderate- to high-risk gamblers show a gambling approach bias and whether this bias was related prospectively to gambling behaviour and problems. **Design** Cross-sectional assessment study evaluating the concurrent and longitudinal correlates of gambling approach bias in moderate- to high-risk gamblers compared with non-problem gamblers. **Setting** Online study throughout the Netherlands. **Participants** Twenty-six non-treatment-seeking moderate- to high-risk gamblers and 26 non-problem gamblers community-recruited via the internet. **Measurements** Two online assessment sessions 6 months apart, including self-report measures of gambling problems and behaviour (frequency, duration and expenditure) and the gambling approach avoidance task, with stimuli tailored to individual gambling habits. **Findings** Relative to non-problem gamblers, moderate- to high-risk gamblers revealed a stronger approach bias towards gambling-related stimuli than neutral stimuli ($P = 0.03$). Gambling approach bias was correlated positively with past-month gambling expenditure at baseline ($P = 0.03$) and with monthly frequency of gambling at follow-up ($P = 0.02$). In multiple hierarchical regressions, baseline gambling approach bias predicted monthly frequency positively ($P = 0.03$) and total duration of gambling episodes ($P = 0.01$) 6 months later, but not gambling problems or expenditure. **Conclusions** In the Netherlands, relative to non-problem gamblers, moderate- to high-risk gamblers appear to have a stronger tendency to approach rather than to avoid gambling-related pictures compared with neutral ones. This gambling approach bias is associated concurrently with past-month gambling expenditure and duration of gambling and has been found to predict persistence in gambling behaviour over time.

Keywords Action tendency, approach bias, approach–avoidance task, dual-process model, gambling behaviour, gambling problems.

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INTRODUCTION

Gambling and substance use disorders (SUD) share many psychopathological features and brain and behavioural mechanisms [1,2], which played a role in the re-classification of gambling disorder into the substance-related and addictive disorders category in the DSM-5 [3]. Cognitive and neurobiological theories of addiction, such as dual-process models [4–6] and the incentive sensitization theory [7], may offer a framework for understanding why some individuals transition to problematic gambling, with serious negative consequences for their personal life and/or health.

Dual-process models conceptualize addiction as the result of a disrupted interplay between two intertwined but qualitatively different classes of cognitive processes, i.e. bottom-up cue-elicited impulsive processes and top-down reflective processes [4–6]. Impulsive processes involve fast, effortless and associative reactions towards stimuli in the environment. Impulsive processes are seen as an evolutionarily 'older' class of cognitive processes and naturally result in more instinctive behaviour [8]. Reflective processes are generally slower and more effortful processes, including emotion- and behaviour-regulation processes, which accommodate flexible learning and adaptation. They involve deliberate and goal-orientated decision-making, resulting from multiple reiterations of re-processing and integration of information inputs with motivational states and current goals to achieve an optimal response selection [9]. In addiction, the interplay between impulsive and reflective processes is thought to become maladaptive, with impulsive processes gaining in strength (reward-related sensitized reactions to substance-related cues [7]) and reflective processes being 'too late' or 'too slow' to efficiently modulate them, leading to the enactment of behavioural impulses that do not match long-term goals.

Biases in the processing of appetitive cues in the environment include the ability of substance-related cues to (a) recruit attentional resources selectively (attentional bias), (b) trigger affective, arousal and motivational implicit memory associations (memory bias) and (c) activate the behavioural schemata associated with the rewarding outcome, which endow the individual with a behavioural 'preparedness' to seek out the expected reward, bringing him/her into the proximity of drugs (approach bias) [6,10]. If strong enough, these hypersensitized impulsive motivational processes gain priority over goal-relevant alternative behaviours and moderating them becomes difficult for slower reflective processes.

In gambling addiction, gambling-related cues and contexts appear to take on increased incentive salience, becoming 'motivational magnets' driving behaviour [11,12]. Studies examining cognitive biases in gambling have focused so far only on attentional bias and on memory associations. Both problematic and pathological gamblers, relative to healthy regular gamblers, exhibited enhanced attentional processing of gambling-related cues compared to neutral cues [13–19]. A recent series of studies examining the role of implicit (i.e. measured indirectly with reaction-time tasks) and explicit (i.e. measured with self-report questionnaires) memory associations between gambling and positive outcomes showed that positive implicit memory associations were associated with greater gambling involvement and more gambling-related problems, and uniquely predicted gambling behaviour above and beyond explicit outcome expectancies [20–22].

The present study

To date, automatically activated approach tendencies towards gambling stimuli have not been studied. Due to the inclusion of a behavioural component over attentional processes and memory associations, approach tendencies link emotion, motivation and behaviour activation [23] and have been found to contribute uniquely to dysregulated substance use [24]. The goal of the present study was to evaluate the cross-sectional and longitudinal correlates of gambling-related approach tendencies in non-treatment-seeking moderate- to high-risk gamblers, compared to regular non-problem gamblers, by adapting the Approach Avoidance Task (AAT) [25,26] to the gambling context. In this task, participants react to stimuli with 'pushing' and 'pulling' responses, based on a feature of the stimulus unrelated to its content (e.g. picture orientation or format). 'Pull' and 'push' responses are disambiguated by a zooming feature, which generates the feeling of approach and avoidance [27]. A faster 'pull' than 'push' response to appetitive substance-related stimuli, relative to neutral stimuli, is interpreted as an indicator of an approach tendency towards the addiction-related cues. With different varieties of the AAT, heavy drinkers [26], alcohol-dependent patients [28–30], smokers [31,32], heroin abusers [33] and heavy cannabis users [34] showed an approach bias towards their substance of abuse.[1] Moreover, the strength of the approach bias has been related to consumption escalation across substances [30,31,34].

Similar to previous studies evaluating stimulus-specific attentional bias towards alcohol [35], stimuli presented in our AAT portrayed gambling-related cues tailored to participants' gambling habits. A typical 'one size fits all' approach to stimulus selection would not congruously match the specific gambling habits of different gamblers, as many of those stimuli would be of limited or no relevance to any given participant, hampering the internal reliability and construct validity of the task [36]. Stimuli thus matched the two most familiar gambling activities selected by participants [37].

Participants took part in two assessment sessions 6 months apart. We investigated whether (a) at baseline, moderate- to high-risk gamblers showed a greater approach bias towards gambling cues in comparison to non-problem gamblers, (b) whether gambling approach bias was associated positively with gambling behaviour (i.e. time and money spent gambling) and (c) whether gambling approach bias predicted prospective gambling behaviour and severity of gambling problems.

[1]In both Martin Braunstein *et al.* (2016) [30] and Zhou *et al.* (2012) [33], a relevant-feature version of the AAT was used where participants had to react directly to the content of the pictures (e.g. alcohol versus non-alcohol) with push and pull responses, which is a less implicit measure of automatically activated approach tendencies.

METHODS

Design

Consistent with previous studies exploring gambling attentional bias [15,17,18] and with approach bias studies in SUD [33,34], in which participants were selectively recruited based on the presence or absence of alcohol or gambling problems, two groups of adult (18+) gamblers (i.e. 26 moderate- to high-risk gamblers and 26 non-problem gamblers) with or without gambling problems were community-recruited via social media and online advertisement on gambling websites and forums in the Netherlands. Moderate- to high-risk gamblers were included if they (i) scored three or more (i.e. at least moderate-risk gamblers) on the Problem Gambling Severity Index (PGSI) [38], (ii) were not seeking help for gambling problems and (iii) gambled at least three times during the past 2 months (not including lottery tickets[2]). Non-problem gamblers were selected with the same criteria except for the PGSI score, which had to be lower than three (i.e. non-problem and low-risk gamblers). Participant inclusion was fully automatized; the online system stopped recruiting participants in one (or the other) group once the quota (*n*) for each group was filled, precluding further participation of any potential gambler fulfilling the inclusion criteria for that group.

Participants completed two online assessment sessions 6 months apart. At baseline, participants responded to some demographics questions and selected the two gambling activities with which they were most familiar and played the most out of four categories (i.e. roulette and dice, card games, slot machines and sports and racetrack betting). Both sessions included the PGSI, a measure of habitual gambling behaviour (gambling time-line follow-back, G-TLFB [42]) and the gambling AAT (G-AAT). To control for alcohol use, severity of drinking problems was also assessed at baseline with the Alcohol Use Disorder Identification Test (AUDIT [43]).

Participants

Upon inclusion, participants provided digital informed consent to participate and completed the baseline assessment, followed by an invitation e-mail after 6 months to participate in the follow-up. Participants were compensated with an online voucher of €17 for the baseline session and €25 for the follow-up. The study was approved by the Ethics Committee of the University of Amsterdam (protocol number: 2015-DP-4112).

Although not a recruitment criterion, the sample was composed of males only. Three participants were excluded due to fraudulent data (i.e. screening of activity and data logs on the online platform showed that at least one participant created three 'fake' accounts on the study platform, probably to earn more compensation vouchers). One additional participant was excluded due to a very low accuracy on the G-AAT at both time-points (proportion of correct responses $< 70\%$). This left 22 moderate- to high-risk gamblers and 26 non-problem gamblers [mean age = 30.42, standard deviation (SD) = 8.64, range = 20–59], 41 of whom (85.4%) returned at the 6-month follow-up. The majority of moderate- to high-risk gamblers (81.8%) experienced moderate levels of gambling-related problems ($3 \leq \text{PGSI} \leq 7$). At baseline, moderate- to high-risk gamblers showed a greater prevalence of loved ones with gambling problems and spent more money on gambling (see Table 1). For both groups there was no indication of changes in gambling behaviour and problems over time, except for a general decline in gambling frequency.

Materials

Questionnaires at baseline and follow-up

Baseline demographic questions included completed education level and presence of any loved ones with gambling problems. The PGSI is a nine-item questionnaire assessing frequency of problematic gambling behaviour and negative experiences as a result of gambling in the past 12 months (and 6 months at follow-up) on a four-point Likert scale (from 0 = never to 3 = almost always). In the current study, the PGSI showed adequate internal consistency (Cronbach's $\alpha_{\text{baseline}} = 0.72$, $\alpha_{\text{follow-up}} = 0.71$) and sufficient test–retest reliability ($\rho_{(39)} = 0.43$, $P = 0.005$).

Habitual gambling behaviour was assessed with the G-TLFB by using a retrospective calendar covering the past 31 days [42]. Two indices of gambling behaviour were assessed per day: total duration (time spent on gambling) and risk (total amount wagered). A monthly sum score for each dimension was computed in addition to the total amount of days gambled in the past month (i.e. gambling frequency) [42]. All G-TLFB indices showed satisfactory test–retest reliability (frequency: $\rho_{(39)} = 0.52$, $P = 0.001$; duration: $\rho_{(39)} = 0.59$, $P < 0.001$; risk: $\rho_{(38)} = 0.67$, $P < 0.001$).

Gambling approach avoidance task

A key-press version of the AAT was used to assess online gambling approach bias [37,44,45]. Participants were instructed to approach ('pull') or avoid ('push') gambling-

[2]For the purposes of this study, playing lottery tickets was not included as gambling activity because lottery play does not appear to be as addictive as other forms of gambling [39] and appeals more to social than to pathological gamblers [40,41].

Table 1 Characteristics of moderate- to high-risk and non-problem gamblers at baseline and 6-month follow-up.

Measure	Baseline: Moderate- to high-risk gamblers	Baseline: Non-problem gamblers		6-month follow-up: Moderate- to high-risk gamblers	6-month follow-up: Non-problem gamblers		Time effect
n	22	26		19	21		
PGSI, mean (SD)	5.32 (2.48)	1.08 (0.84)		3.89 (3.23)	1.43 (1.21)		$F_{(1, 38)} = 1.19$, $P = 0.28$
Baseline characteristics							
Age, mean (SD)	29.68 (9.24)	31.04 (8.23)	$t_{(46)} = 0.54$, $P = 0.59$	–	–		
Education level, *n* (%)			$\chi^2_{(2, 48)} = 1.85$, $P = 0.40$				
Primary education	2 (4.2%)	1 (2.1%)		–	–		
Secondary education	13 (27.1%)	12 (25%)		–	–		
University degree or higher	7 (14.6%)	13 (27.1%)		–	–		
Gambling problems in loved ones, *n* (%)	13 (27.1%)	5 (10.4%)	$\chi^2_{(1, 48)} = 8.08$, $P = 0.007$	–	–		
AUDIT, mean (SD)	8.86 (5.37)	6.69 (4.31)	$U = 221.50$, $Z = -1.34$, $P = 0.18$	–	–		
Chosen gambling activities, *n* (%)			$\chi^2_{(1,48)} = 0.17$, $P = 0.68$				
Card games/betting	10 (20.8%)	12 (25%)		–	–		
Card games/slots	4 (8.3%)	6 (12.5%)		–	–		
Card games/roulette	4 (8.3%)	5 (10.4%)					
Roulette/slots	2 (4.17%)	2 (4.17%)		–	–		
Roulette/betting	2 (4.17%)	1 (2.1%)					
Gambling outcomes							
G-TLFB frequency (No. days gambled), mean (SD)	9.46 (4.82)	8.68 (7.80)[a]	$U = 218$, $Z = -1.22$, $P = 0.22$	6.95 (4.84)	5.81 (8.12)	$U = 144.5$, $Z = -1.51$, $P = 0.13$	$F_{(1, 38)} = 4.8$, $P = 0.04$
G-TLFB duration (in mins), mean (SD)	1249.96 (801.32)	1225.38 (1516.81)[b]	$U = 213$, $Z = -1.22$, $P = 0.26$	1142.84 (945.67)	864.52 (1464.08)	$U = 143.5$, $Z = -1.54$, $P = 0.12$	$F_{(1, 38)} = 0.30$, $P = 0.59$
G-TLFB money risked (in €), mean (SD)	1811.38 (3816.32)	726.08 (1963.26)[b]	$U = 152.00$, $Z = -2.28$, $P = 0.023$	692.74 (666.68)	1163.98 (3442.29)	$U = 135$, $Z = -1.76$, $P = 0.08$	$F_{(1, 38)} = 0.09$, $P = 0.77$
Approach bias scores							
Gambling approach bias (in ms), mean (SD)	25.96 (68.63)	1.96 (57.00)		23.34 (72.73)	−19.55 (36.62)		
Neutral approach bias (in ms), mean (SD)	−10.64 (48.65)	5.25 (55.71)		11.68 (67.76)	−13.31 (28.24)		

Group differences in the baseline variables were tested with χ^2 statistics (education level, gambling problems in loved ones, chosen gambling activities), *t*-tests (age) and, when normality assumptions were violated, Mann–Whitney *U*-tests (AUDIT and G-TLFB indices). Changes in G-TLFB and PGSI scores over time were examined with repeated-measures analysis of variance. SD = standard deviation. [a]$n = 25$, one participant did not provide data for this G-TLFB index; [b]$n = 24$, two participants did not provide data for these G-TLFB indices.

related and neutral pictures by responding as quickly and accurately as possible to the rotation direction (5 degrees) of the pictures with two keys on the keyboard (see the Supporting information for a detailed description of the task). Stimuli were drawn from a large set of pictures displaying gambling cues for the four gambling activities (i.e. roulette and dice, card games, slot machines and sports and racetrack betting), and with control stimuli depicting everyday objects or activities unrelated to gambling [37] (see Supporting information, Fig. S1 for some stimulus examples). The same random selection of 16 gambling-related pictures (eight per chosen gambling category) and 16 control pictures was presented in the task at both time-points.

Following the recommendations of Fazio (1990) [46] and consistent with previous studies [24–26], approach bias indices were computed based on median reaction times (RTs) in order to minimize the influence of outlying responses and skewness of RT distributions. Approach bias scores were calculated by subtracting median RTs for correct responses to approach and avoid trials for each stimulus category: (gambling/push – gambling/pull) and (neutral/push – neutral/pull). A positive score indicated relatively faster RTs for approach responses compared to avoid, hence an approach bias.

Both gambling and neutral approach bias scores showed a moderate split-half reliability (see the Supporting information for its computation) at both time-points [$\rho_{\text{gambling baseline}} = 0.27$, 95% confidence interval (CI) = (0.04, 0.50); $\rho_{\text{gambling follow-up}} = 0.27$, 95% CI = (−0.03, 0.55); $\rho_{\text{neutral baseline}} = 0.19$, 95% CI = (−0.07, 0.43); $\rho_{\text{neutral follow-up}} = 0.26$, 95% CI = (−0.06, 0.55)]. Gambling approach bias scores further showed a moderate test–retest reliability ($\rho_{(38)} = 0.42$, $P = 0.007$), while neutral approach bias scores showed a lower and non-significant test–retest reliability ($\rho_{(38)} = 0.18$, $P = 0.25$).

Data analysis

Baseline approach bias scores were analysed with a mixed analysis of variance (ANOVA) with stimulus and group as within- and between-subject factors, respectively. Paired-sample *t*-tests were used for within-group post-hoc comparisons. Spearman's correlation coefficients were computed between the G-TLFB indices and gambling approach bias scores at each time-point. Finally, in order to establish gambling approach bias as a significant univariate predictor of 6-month gambling problems, duration, frequency and expenditure, four stepwise hierarchical regression analyses were conducted with baseline gambling approach bias entered as predictor in the second step, after controlling for baseline level of the gambling outcome in question and neutral approach bias scores in the first step.

RESULTS

Group difference in gambling approach bias

The mixed ANOVA on the baseline approach bias scores did not identify any statistically significant main effects of stimulus category ($F_{(1,46)} = 3.83$, $P = 0.06$, $\eta^2_p = 0.08$) or group, ($F_{(1,46)} = 0.08$, $P = 0.78$, $\eta^2_p = 0.00$), but did show a significant stimulus × group interaction ($F_{(1,46)} = 5.49$, $P = 0.02$, $\eta^2_p = 0.11$). Moderate- to high-risk gamblers exhibited a greater approach bias towards gambling stimuli relative to neutral ones [mean difference = 36.59, 95% CI mean difference = (10.74, 62.44), $t_{(21)} = 2.94$, $P = 0.008$, $d = 0.65$], while non-problem gamblers showed similar tendencies towards the two types of stimuli [mean difference = −3.29, 95% CI mean difference = (−27.16, 20.58), $t_{(25)} = -0.28$, $P = 0.78$; see Fig. 1]. A mixed ANOVA including time as additional within-subject factor showed similar results (see Supporting information).

Correlation analyses

The correlation results presented in Table 2 show a significant concurrent association between gambling approach bias and gambling expenditure at baseline and gambling approach bias and time spent gambling at follow-up.

Hierarchical regression analyses

Baseline gambling approach bias predicted 6-month gambling outcomes significantly only in two cases: monthly frequency and total duration of gambling (see Table 3). The final hierarchical models showed that baseline gambling approach bias predicted positively both frequency and total duration of gambling after 6 months, over and above baseline neutral approach bias and gambling frequency (total

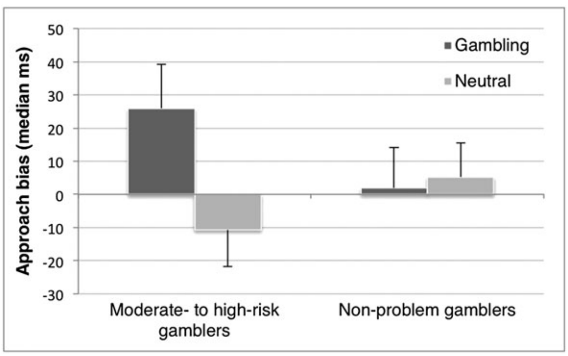

Figure 1 Baseline approach bias scores (median RT_{push} − median RT_{pull}) for gambling and neutral stimuli in moderate- to high-risk and non-problem gamblers (mean with standard error bars). A positive score indicates faster responses to pull (approach) trials compared to push (avoid) trials. Moderate- to high-risk gamblers showed a greater tendency to approach gambling stimuli relative to neutral ones ($P = 0.008$), while non-problem gamblers responded similarly to both stimulus categories

Table 2 Correlation analysis over the full sample between concurrent gambling approach bias and indices of gambling behaviour at each time-point: Spearman's rho (ρ), degrees of freedom (d.f.), *P*-value (*P*) and 95% confidence interval (95% CI).

	Gambling approach bias			
	ρ	*d.f.*	*P*	*95% CI*
Baseline				
G-TLFB frequency	−0.02	45	0.92	(−0.28, 0.25)
G-TLFB duration	0.15	45	0.33	(−0.12, 0.39)
G-TLFB expenditure	0.33	45	0.03	(0.07, 0.58)
Six-month follow-up				
G-TLFB frequency	0.28	40	0.08	(−0.02, 0.53)
G-TLFB duration	0.37	40	0.02	(0.10, 0.60)
G-TLFB expenditure	0.17	40	0.28	(−0.09, 0.45)

95% CI was computed using bias corrected and accelerated (BCa) bootstrapped intervals, with cases resampled n = 1000 times, stratified by group. G-TLFB = Gambling time line followback.

$R^2 = 0.49$, $F_{(3,35)} = 11.41$, $P < 0.001$) and duration (total $R^2 = 0.50$, $F_{(3,35)} = 11.42$, $P < 0.001$), respectively.

DISCUSSION

This study is the first to examine automatic action tendencies towards gambling cues, as measured with the AAT, in non-treatment-seeking gamblers with moderate-to-high severity of gambling problems, compared to a control group of non-problem gamblers. Relative to non-problem gamblers, moderate- to high-risk gamblers revealed a stronger tendency to approach rather than to avoid gambling-related pictures compared to neutral ones. As predicted, gambling approach bias was associated concurrently with past-month gambling expenditure at baseline and duration of gambling at follow-up. Further, a stronger baseline gambling approach bias predicted maintenance in both frequency and duration of gambling episodes after 6 months. No significant association was found between

Table 3 Hierarchical multiple regression analysis of gambling approach bias predicting gambling frequency, duration, expenditure and problems at 6-month follow-up.

	Step 1			*Step 2*		
Predictors	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Outcome: 6-month G-TLFB frequency (No. days gambled)						
Baseline G-TLFB frequency	0	0.107	0.646***	0.537	0.101	0.637***
Baseline neutral approach bias	−0.006	0.013	−0.056	−0.022	0.015	−0.215
Baseline gambling approach bias				0.027	0.012	0.310*
Change in R^2		0.42			0.07	
F for change in R^2		$F_{(2,36)} = 13.21$, $P < 0.001$			$F_{(1,35)} = 4.92$, $P = 0.033$	
Outcome: 6-month G-TLFB duration						
Baseline G-TLFB duration	0.519	0.115	0.589***	0.451	0.109	0.512***
Baseline neutral approach bias	4.189	2.282	0.240	0.611	2.477	0.035
Baseline gambling approach bias				5.641	2.067	0.392**
Change in R^2		0.39			0.11	
F for change in R^2		$F_{(2,36)} = 11.37$, $P < 0.001$			$F_{(1,35)} = 7.45$, $P = 0.01$	
Outcome: 6-month G-TLFB expenditure						
Baseline G-TLFB expenditure	0.412	0.047	0.811***	0.408	0.046	0.803***
Baseline neutral approach bias	3.197	1.562	0.189*	1.691	1.836	0.100
Baseline gambling approach bias				2.281	1.524	0.163
Change in R^2		0.70			0.02	
F for change in R^2		$F_{(2,35)} = 41.12$, $P < 0.001$			$F_{(1,34)} = 2.24$, $P = 0.14$	
Outcome: 6-month PGSI						
Baseline PGSI	0.549	0.116	0.612***	0.526	0.121	0.587***
Baseline neutral approach bias	−0.005	0.005	−0.136	−0.008	0.006	−0.193
Baseline gambling approach bias				0.004	0.005	0.116
Change in R^2		0.39			0.01	
F for change in R^2		$F_{(2,36)} = 11.72$, $P < 0.001$			$F_{(1,35)} = 0.56$, $P = 0.46$	

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$. B = unstandardized regression coefficient; SE = standard error; β = standardized regression coefficient. Prior to the analyses, the data were screened for multivariate outliers on the basis of high influence above common cut-offs [standardized DFFITS $>2\sqrt{((k + 1)/n}$ and Cook's $d > 4/n$] and standardized residual > 3. The same multivariate outlier (a non-problem gambler) was detected across all G-TLFB outcomes (standardized DFFITS and Cook's d values > 0.63 and 0.1, respectively, and standardized residual > 3) and was removed from the G-TLFB regression analyses. A different outlier (moderate- to high-risk gambler) was removed in the regression analysis of the PGSI for the same reason. Results of the regression analyses including the removed outliers are presented in Table S2 in the Supporting information.

gambling approach bias and escalation in severity of gambling problems or expenditure.

The first result suggests that, for moderate- to high-risk gamblers, gambling cues are not only attention-grabbing [13–19] and triggers of positive memory associations [20–22], but also elicit automatically a motor response of approach towards them. Thus far, approach tendencies assessed with the AAT have been found for different addictions [26,28–34], suggesting common dysregulated cognitive motivational processes [5,6] and biased information processing of substance-related cues associated with the expected reward [7]. The result that, similarly to SUD, gambling cues trigger the corresponding behavioural schema to approach them in moderate- to high-risk gamblers, provides additional evidence for the presence of automatic incentive habits involved in addictive behaviours not involving the neurotoxic effects of substance consumption, but resulting from the reinforcement deriving from the performance of a behaviour for its own sake, such as gambling.

The second result of this study, i.e. the concurrent positive correlation between gambling approach bias with gambling expenditure and, particularly, monthly gambling duration, further supports the idea that persistent gambling involvement may be coupled with associations that link the hedonic effects of gambling (e.g. positive affect), the stimuli present in the environment (e.g. gambling machines or venues) and the behavioural schema that has led to the positive affect (e.g. the action of gambling). As a consequence, gambling-related cues acquire a strong incentive value and activate this associative cluster, which further increases the likelihood of engaging in and maintaining gambling behaviour, as demonstrated by the third result of this study: that a relatively greater tendency to approach rather than avoid gambling cues predicts positively both the frequency and total duration of gambling episodes during a 6-month window. These results are consistent with previous studies in alcohol and smoking, where substance-related approach tendencies predicted increases in prospective substance consumption [30,31,34]. Further, gambling approach bias explained 7% and 11% variance in gambling frequency and duration above and beyond baseline levels of each gambling outcome and approach bias for neutral cues.

To our knowledge, this study is the first to highlight the role of motivational approach tendencies in the course of gambling behaviour and provides initial support for the idea that approach bias may contribute to the continuation of gambling behaviour, possibly from the early, goal-directed and recreational stage to the later, more compulsive and problematic phase. Unfortunately, the small sample size at follow-up excluded the inclusion of group assignment in the regression analyses, which could have evidenced any differential effects of approach bias on maintenance of gambling behaviour across the two groups. Further, there was no significant increase in gambling behaviour, or severity of gambling problems, during the 6 months in either group, limiting the possibility of establishing whether gambling approach bias fosters a shift towards more severe gambling problems. Further research could include a longer follow-up window and larger samples of gamblers at different stages of problem gambling severity (i.e. low-risk, moderate-risk, pathological gambling), compared to non-gambler controls and abstaining pathological gamblers [18], to both ensure greater generalizability of the results and explore the moderating effect of psychopathology status on the relationship between approach bias and prospective gambling involvement.

Contrary to our hypothesis, gambling approach bias did not predict any changes in severity of gambling problems, inconsistent with some [34] but consistent with other SUD studies [32,34] and studies of attentional bias in problem gamblers [13,16]. This result may be related to the absence of any change in gambling problems from baseline to follow-up and to the majority of the sample experiencing no or moderate levels of gambling problems —hence, the relatively small variance in PGSI scores [13,16].

Limitations

A first limitation in this study that may confound the interpretation of results is the lack of a measure of age of gambling onset. Given the greater proportion of moderate- to high-risk gamblers with loved ones with gambling problems, the lack of such a measure ruled out accounting for the potential effects of long-lasting familiarity with and indirect or passive exposure to gambling, or the duration of the individual's gambling history, which has also been found to predict involvement and escalation of various gambling activities [47]. This is particularly relevant when considering that the two groups did not differ substantially in any of the baseline indices of past-month gambling behaviour (except for baseline expenditure), probably implying similar schedules and intensity of gambling involvement. A second limitation concerns the absence of a measure of gambling urges, which precluded further testing whether the activation of automatic approach tendencies for gambling cues tailored to individual gambling habits was indeed associated with the subjective experience of craving, resulting possibly from the strong 'wanting' urge triggered by the exposure to the incentivized cues [7].

One last important issue to bear in mind concerns the online setting of this study: non-treatment-seeking gamblers were recruited via online gambling websites and forums, flagging the monetary compensation for participating in the study. It appeared that at least one participant created fake accounts on the study platform, with the obvious goal of earning more money. Despite questioning the legitimacy of the results, the possibility of efficiently detecting these 'suspicious' fraudster accounts by screening multiple log indices of online activity (e.g. IP addresses, e-mail addresses, time stamps) ensured a satisfactory degree of confidence in the veracity of the remaining data entries. However, this occurrence should serve as a caution to future research, particularly with this population and when the degree of experimental control is low, as in online studies.

CONCLUSION

The results of the current study contribute to the existing evidence regarding shared neurocognitive and neurobiological processes between gambling and SUD [1,2]. Similar to the presence of disturbances in reinforcement learning, reward processing and cognitive control, with similar changes in the neurocircuitry involved, gambling problems also involve the expression of endophenotypical markers of sensitized, implicit motivational processes towards gambling-related cues [48], such as attentional and memory biases and, as of now, automatic approach tendencies. As a strong approach bias towards gambling increases the likelihood of persisting in gambling, which implies the risk of ultimately exacerbating gambling problems, it is reasonable to propose that neurocognitive interventions targeting these dysfunctional implicit motivational processes, e.g. retraining selective attention and approach bias via cognitive bias modification (CBM) [6], may reduce the risk of problem gambling escalation and/or relapse [37]. By reducing effectively the coding of salient cues in the brain reward system [49], CBM training programmes have the potential of re-wiring action-value representations associated with appetitive gambling cues, particularly when using gambling stimuli tailored to the individual's most familiar and frequently played gambling activities.

Declaration of interests

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Supporting Information

Additional Supporting Information may be found online in the supporting information tab for this article.

Figure S1 Exemplars of pictures used in the gambling approach avoidance task.

Table S2 Hierarchical multiple regression analysis of gambling approach bias predicting gambling frequency, duration, expenditure and problems at follow-up, including the removed outliers (one non-problem gambler in the G-TLFB frequency, duration and expenditure analyses; one moderate- to high-risk gambler in the PGSI analysis).