Addictive Behaviors 145 (2023) 107778

Contents lists available at ScienceDirect

Addictive Behaviors

journal homepage: www.elsevier.com/locate/addictbeh

# Losing sight of Luck: Automatic approach tendencies toward gambling cues in Canadian moderate- to high-risk gamblers – A replication study

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ARTICLE INFO

*Keywords:*
Approach bias
Automatic cognitive bias
Approach–avoidance task
Gambling behaviour
Problematic gambling
Replication study

ABSTRACT

Evidence for approach bias tendencies to underly automatic behavioural impulses towards seeking out gambling activities in the presence of appetitive salient cues was first shown by Boffo et al. (2018) in a Dutch sample. Relative to non-problem gamblers, moderate-to-high-risk gamblers demonstrated stronger approach tendencies towards gambling-related stimuli compared with neutral ones. Moreover, gambling approach bias was associated with past-month gambling behaviour and predictive of gambling activity persistence over time. The current study aimed to replicate these findings within a Canadian sample evaluating the concurrent and longitudinal correlates of gambling approach bias. The study was conducted online, available throughout Canada. Twenty-seven non-treatment-seeking moderate-to-high-risk gamblers and 26 non-problem gamblers community-recruited via multiple channels (i.e., internet and newspaper advertisements, land-based flyers, and university recruitment portals). Participants completed two online assessment sessions 6-months apart. Each session included (1) self-report measures of gambling behaviour (frequency, duration, and expenditure), (2) self-report assessment of problem gambling severity (PGSI), and (3) a gambling approach-avoidance task, utilising culturally relevant stimuli tailored to individual gambling habits. However, our study failed to replicate Boffo et al. (2018) findings in a Canadian sample. Relative to non-problem gamblers, moderate-to-high-risk gamblers did not exhibit greater approach bias tendencies towards gambling-related stimuli compared to neutral stimuli. Moreover, gambling approach bias was not predictive of prospective gambling behaviour (frequency, duration, or expenditure) or severity of gambling problems. Reported results do not provide evidence for approach tendencies contributing to problematic gambling behaviour in a Canadian sample of moderate-to-high-risk gamblers compared to non-problematic gambler controls. Further replications on the topic are needed. Future research should evaluate approach tendencies within the gambling context, considering the potential impact of task reliability to assess approach bias in light of individual gambling modality preferences.

## 1. Introduction

Over the past decade, the accessibility of gambling has rapidly increased, accelerated by the legalisation of online gambling in many countries worldwide. More recently, in response to the COVID-19 pandemic, gambling has transitioned from predominantly a land-based (e.g., casino) activity to a multi-modal form of entertainment (e.g., web and mobile-play). However, as the impact of these developments on gambling involvement and psychopathology becomes more apparent (i.e., increased incidence of problematic gambling (PG) and harm escalation; Brodeur et al., 2021; Price, 2020; Sachdeva et al., 2022), it is of high priority for both policymakers and clinicians to examine factors that precipitate the onset of PG, deter gambling discontinuation, or trigger relapse. While structural and situational characteristics of gambling products themselves (e.g., reward schedules and/or game features; McCormack & Griffiths, 2013) are known risk factors for the

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https://doi.org/10.1016/j.addbeh.2023.107778
Received 16 January 2023; Received in revised form 20 April 2023; Accepted 14 June 2023
Available online 18 June 2023

development of PG, motivational and control processes known to play a role in substance use disorders are still being probed within the gambling context. Specifically, research on 'implicit associations' derived from theories on addiction (e.g., models emphasizing a role for automatically activated cognitive motivational processes) have begun to provide insights into the psychological mechanisms underlying PG behaviour (Hønsi et al., 2013).

In line with these theories, PG behaviour may arise due to biased decision-making processes (Korteling et al., 2018; Wiers & Verschure, 2021). Facilitated by repetitive engagement with gambling activities, gambling cues are proposed to automatically activate associative responses, influenced by the value and individual sensitivity to an expected outcome (i.e., reward). Over time, underlying motivational processes are affected, favouring the choice to initiate gambling when triggered by conditioned internal and environmental cues (Hommel & Wiers, 2017; Rochat et al., 2019). The hypersensitisation to gambling cues more readily recruit attentional resources (i.e., attention bias), which activate affective memory associations of an anticipated reward (i.e., memory bias; Wiers et al., 2013). Thus, the heightened cue incentive salience diminishes top-down functions essential for reflective processing (i.e., goal-orientated decision-making) as choice competition is biased towards enacting on behavioural impulse (i.e., bottom-up, automatic responding to cue-elicited gambling availability; Robinson & Berridge, 2008). Consequently, the attainment of long-term or alternative goals may be devalued. Even as aversive consequences of gambling escalate (e.g., financial instability or mental health problems), gambling behaviour may be maintained in service of short-term reward gratification (Field et al., 2020; Wiers et al., 2021).

The behavioural impulse component to seek out gambling activities (i.e., behavioural preparedness) in the presence of appetitive salient cues is commonly referred to as *approach bias* (Stacy & Wiers, 2010; Wiers et al., 2009). Research in other addictive behaviours has demonstrated how biased approach tendencies distinctively contribute to dysregulated substance (mis)use, predicting the increase in prospective consumption (e.g., in problematic use of alcohol and cannabis; Cousijn et al., 2011; Fleming & Bartholow, 2014; Sharbanee et al., 2013). However, in the field of gambling research, so far, only one published study has investigated approach bias to motivationally salient gambling cues and whether the hypothesized approach bias predicts problematic gambling behaviour (Boffo et al., 2018).[1]

In a Dutch sample, Boffo et al. (2018) compared gambling approach bias in non-treatment-seeking moderate-to-high-risk gamblers vs. non-problematic gamblers. Utilising a gambling variant of the Approach Avoidance Task (G-AAT; Wiers et al., 2009) to evaluate differential responding speed to appetitive, gambling-related vs neutral, non-gambling-related cues, results showed that moderate-to-high-risk gamblers displayed a stronger approach bias to gambling-related stimuli in comparison to non-problematic gamblers. Moreover, gambling approach bias was found to predict the persistence of gambling behaviour over time such that bias strength positively predicted higher monthly gambling frequency and longer total duration of gambling episodes at 6-month follow-up.

### 1.1. The present study

To extend the literature concerning approach bias in gambling and its predictive value in gambling behaviour, the present study was initially conducted in parallel to Boffo et al. (2018). The original multi-lab design intended to provide a cross-cultural examination (i.e., Dutch vs Canadian cohorts) of gambling approach bias in problematic and non-problem gamblers. However, during the design phase, Canadian researchers had been denied access to Canadian land-based gambling venues to source and create gambling-related stimuli (photographs) for the Canadian sample specifically. Consequently, the researchers instead implemented an adapted version of the Dutch G-AAT in which the original Dutch stimuli were recreated and/or modified (e.g., branding removed in Dutch casino images). Yet, following a preliminary analysis of baseline data, problem gamblers within the Canadian sample demonstrated an unexpected aversion to the task stimuli. Specifically, moderate-to-high-risk gamblers showed a negative approach bias (i.e., an avoidance bias) towards gambling stimuli, but not for neutral stimuli. Moreover, an unexpected negative correlation between gambling approach bias and gambling severity emerged, suggesting that a greater severity in gambling-related problems lead to a greater tendency to avoid (rather than approach) gambling stimuli (Salmon et al., 2016).

Given these highly unanticipated findings, the researchers speculated that they may have resulted from utilizing culturally inaccurate stimuli, possibly inducing an 'uncanny valley' effect (cf., MacDorman, 2005; Salmon et al., 2016). Thus, the stimulus unfamiliarity to the Canadian participants may have induced feelings of uneasiness, leading to aversion responses. Such rationale was supported by post-hoc analyses showing that Canadian gamblers exhibited a greater aversion to the photoshopped images of the Dutch stimuli than the equivalent images taken from Canadian sources (Salmon et al., 2016). Consequently, the Canadian study was terminated and a second attempt to recreate culturally appropriate gambling stimuli for the Canadian population was carried out. The study was launched again with the identical experimental procedure of Boffo et al. (2018) in a new Canadian sample, with moderate-to-high-risk gamblers and non-problem gamblers completing two online sessions six months apart. Participants were assessed on measures of gambling approach bias, gambling behaviour, and problem gambling severity. Similar to Boffo et al. (2018), it was hypothesised that (1) moderate-to-high-risk gamblers would show a greater approach bias towards gambling cues in comparison to non-problem gamblers at baseline, (2) gambling approach bias would be positively associated with gambling behaviour (i.e., time and money spent gambling), (3) baseline gambling approach bias would predict prospective gambling behaviour and severity of gambling problems at 6-month follow-up.

## 2. Method

### 2.1. Participants

Following the protocol of Boffo et al. (2018), criteria for study inclusion selectively recruited two groups of adult participants (>19 years) – namely, moderate-to-high-risk gamblers and non-problem gamblers. Moderate-to-high-risk gamblers were defined as participants (1) who scored $\geq 3$ on the Problem Gambling Severity Index (PGSI; Ferris & Wynne, 2001), (2) were not in treatment or seeking help for gambling problems at the time of recruitment, and (3) had gambled a minimum of three times in the two months prior to participation. The same criteria were applied in selecting the non-problem gamblers group, with the exception that only individuals with a PGSI score $< 3$ were included (i.e., no to low-risk for gambling-related harm).

The final sample (see Table 1) consisted of 26 non-problem gamblers and 27 moderate-to-high-risk gamblers (age: $M = 30.19$, $SD = 8.53$, range = 19–55), 45 of whom returned at the 6-month follow-up (21 non-problem gamblers; 24 moderate-to-high-risk gamblers; 84.9% of initial sample). Level of problem gambling severity within the moderate-to-high-risk group was well distributed with 63.0% at moderate risk of gambling harm ($3 \leq$ PGSI $\leq 7$) and 37.0% high-risk gambling harm ($8 \leq$ PGSI $\leq 18$)]. At baseline, moderate-to-high-risk gamblers spent significantly more money and time gambling and exhibited a general tendency towards greater hazardous alcohol consumption (AUDIT scores: $M =$

[1] Wittekind et al. (2019)conducted a feasibility study on the effectiveness of a web-based Approach Bias Modification training intervention for problematic gambling, consistent with recent efforts to change addictive behaviour by changing automatic associations (see Snippe et al., 2019). However, approach bias was not directly assessed by Wittekind et al. (2019).

**Table 1**
Participants characteristics at baseline and 6-months follow-up.

| | *Baseline* | | | *6-month follow-up* | | | |
|---|---|---|---|---|---|---|---|
| *Measure* | *Moderate- to high-risk gamblers* | *Non-problem gamblers* | | *Moderate- to high-risk gamblers* | *Non-problem gamblers* | | *Time effect* |
| *n* | 27 | 26 | | 24 | 21 | | |
| PGSI, mean (SD) | 7.48 (4.49) | 0.96 (0.77) | | 7.16 (5.24) | 1.84 (2.17) | | $F_{(1, 38)} = 34.85$, $P = 0.81$ |
| **Baseline Characteristics** | | | | | | | |
| Age, mean (SD) | 30.44 (8.36) | 29.92 (8.88) | $t_{(51)} = 0.22$, $P = 0.83$ | – | – | | |
| Gender, *n* (%) | | | $\chi^2_{(1, 52)} = 0.06$, $P = 0.81$ | | | | |
| Male | 20 (37.76) | 20 (37.76) | | – | – | | |
| Female | 7 (13.21) | 6 (11.32) | | – | – | | |
| Education level, *n* (%) | | | $\chi^2_{(5, 52)} = 7.35$, $P = 0.2$ | | | | |
| < High school graduate | – | 2 (3.77) | | – | – | | |
| ≥High school graduate | 11 (20.75) | 7 (13.21) | | – | – | | |
| ≥University graduate | 16 (30.19) | 17 (32.07) | | – | – | | |
| Gambling problems in loved ones, *n* (%) | 13 (24.53) | 12 (22.64) | $\chi^2_{(12, 52)} = 9.65$, $P = 0.65$ | – | – | | |
| AUDIT, mean (SD) | 9.81 (7.41) | 6.19 (4.82) | $U = 452.5$, $Z = 1.81$, $P = 0.07$ | – | – | | |
| Chosen gambling activities | | | $\chi^2_{(5, 52)} = 3.31$, $P = 0.65$ | | | | |
| Cards/Betting | 4 (7.55) | 7 (13.21) | | – | – | | |
| Cards/Slots | 9 (16.98) | 4 (7.55) | | – | – | | |
| Roulette & Dice/Betting | 1 (1.89) | 2 (3.77) | | – | – | | |
| Roulette & Dice/Cards | 5 (9.43) | 4 (7.55) | | – | – | | |
| Roulette & Dice/Slots | 3 (5.66) | 4 (7.55) | | – | – | | |
| Slots/Betting | 5 (19.43) | 5 (9.43) | | – | – | | |
| **Gambling outcomes** | | | | | | | |
| G-TLFB frequency (no. days gambled), mean (SD) | 6.19 (4.91) | 5.12 (5.71) | $U = 416$, $Z = 1.16$, $P = 0.25$ | 5.5 (6.76) | 3.61 (6.83) | $U = 282.5$, $Z = 1.71$, $P = 0.09$ | $F_{(1, 40)} = 1.38$, $P = 0.25$ |
| G-TLFB duration (in mins), mean (SD) | 848.70 (921.18) | 297.12 (345.14) | $U = 479$, $Z = 2.28$, $P = 0.02$ | 2021.5 (5217.87) | 173.17 (252.15) | $U = 306.5$, $Z = 2.33$, $P = 0.02$ | $F_{(1, 40)} = 0.71$, $P = 0.41$ |
| G-TLFB expenditure (in $), mean (SD) | 990.41 (1795.06) | 276.5 (733.72) | $U = 464$, $Z = 2.01$, $P = 0.04$ | 1068.38 (1822.71) | 68.28 (173.74) | $U = 308.5$, $Z = 2.39$, $P = 0.02$ | $F_{(1, 40)} = 0.07$, $P = 0.8$ |
| **Approach bias scores** | | | | | | | |
| Gambling approach bias (in ms), mean (SD) | −1.31 (95.23) | 4.90 (38.08) | | 12.00 (72.87) | 13.47 (38.66) | | |
| Neutral approach bias (in ms), mean (SD) | −6.96 (94.38) | 24.15 (46.36) | | 25.04 (83.99) | 6.07 (55.23) | | |

Group differences in the baseline variables were tested with $\chi^2$ 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. Approach bias score: a score is generated for each stimulus category calculated by subtracting the median RT to pull trials (approach) from push (avoid) trials (i.e., gambling/push – gambling/pull and neutral/push – neutral/pull).

9.81, $SD = 7.41$, higher than the cut -off score of 8 for harmful drinking behaviour, Saunders et al., 1993; see Table 1). As this study solely assessed gambling behaviour without implementing any behaviour change intervention, as expected, both groups' gambling behaviour remained stable over time (i.e., baseline to 6-month follow-up; see Table 1).

### 2.2. Procedure

Study recruitment operated mainly across flyers near casinos and newspaper advertisements, with a few online posts on forums/social media and university research recruitment-portals. Participants registered online and were screened for eligibility. To prevent fraudulent participation as documented by Boffo et al. (2018), the online inclusion procedure employed two screening steps via SMS and email by sending a verification code prior to study acceptance, confirming the participant's unique entry. Group allocation was fully automated such that the online system prevented additional intakes once the quota (*n*) for each group had been fulfilled (see Boffo et al., 2018). Upon inclusion, participants provided digital informed consent and were briefed on participation requirements.

At baseline, demographic information was collected along with gambling activity preferences and alcohol use. Both baseline and 6-month follow-up sessions included the PGSI, a measure of habitual gambling behaviour and the G-AAT. Participants were compensated with online vouchers ($30 at baseline, and $50 at 6-month follow-up). The study was approved by the Health Sciences Research Ethics Board of Dalhousie University, Canada (REF: 2015–3508).

### 2.3. Materials

#### 2.3.1. Questionnaires

Demographic information included age, gender, nationality, highest level of completed education, and incidence of familial gambling problems, and gambling activity preference. Additionally, the following questionnaires were administered: AUDIT, a 10-item questionnaire assessing alcohol use and related problems; the nine-item PGSI, assessing frequency of problematic gambling behaviour and negative experiences as a result of gambling in the past 12-months (baseline) and 6-months (follow-up) on a four-point Likert scale (from 0 = never to 3 = almost always); and the gambling-timeline-follow-back (G-TLFB; Weinstock et al., 2004), a measure of habitual gambling behaviour using a retrospective calendar covering the past 31-days at both time points. The G-TLFB provides three indices of gambling behaviour: (1) total time spent gambling (i.e., gambling duration), (2) total amount of money wagered (i.e., total expenditure) – both calculated daily; and (3) number of days gambled during the previous month (i.e., gambling frequency). All G-TLFB indices showed moderate 6-month test–retest reliability (duration: $\rho_{(45)} = 0.51$, $P < 0.001$; expenditure: $\rho_{(45)} = 0.35$, $P = 0.02$; frequency: $\rho_{(45)} = 0.48$, $P = 0.001$). Additionally, the PGSI showed good internal consistency (Cronbach's α baseline = 0.89, α follow-up = 0.91) and moderate 6-month test–retest reliability ($\rho_{(45)} = 0.45$, $P = 0.002$).

*2.3.2. Gambling approach and avoidance task (G-AAT).*

The study implemented the G-AAT used in Boffo et al. (2018), except for the presented stimuli (see Appendix A & Fig. 1 for stimuli preparation information). The task required participants to respond as quickly and accurately as possible to the rotation (5-degree angle to the left or the right) of neutral and gambling-related stimuli presented on screen via a keypress; either by a push (arrow-up-keypress; avoid) or pull (arrow-down-keypress; approach) action. Following a push response, the stimuli zoomed out (became smaller on-screen) while after a pull response the picture zoomed in (became larger on-screen), intended to enhance the sense of approach or avoidance (see Wiers et al., 2009). The signal to 'push' or to 'pull' was stipulated by the orientation of the image (i.e., to the left or right); the contingency between image orientation and action response (i.e., rotation direction and pull or push response) was counterbalanced within each gambler group. For a detailed overview of task parameters and data pre-processing please refer to Boffo et al. (2018) and Appendix B.

Accuracy rate at baseline and follow-up was high [baseline: $M$ = 91.61%, $SD$ = 7.30; follow-up: $M$ = 91.33%, $SD$ = 8.14]. Internal and test–retest reliability was evaluated for neutral and gambling approach bias at both time points. Split-half reliability analyses were conducted with *multicon* (Sherman, 2014) and *splithalfr* packages (Pronk, 2021). Bootstrapped estimates showed acceptable split-half reliability at both time-points ($\rho_{\text{gambling baseline}} = 0.49$, 95% confidence interval (CI) = [-0.12, 0.78]; $\rho_{\text{gambling follow-up}} = 0.49$, 95% CI = [0.13, 0.72]; $\rho_{\text{neutral baseline}} = 0.69$, 95% CI = [0.49, 0.84]; $\rho_{\text{neutral follow-up}} = 0.64$, 95% CI = [0.36, 0.85]). However, test–retest reliability for both bias indices was modest (gambling approach bias $\rho_{(41)} = 0.29$, $P = 0.06$; neutral approach bias $\rho_{(41)} = 0.25$, $P = 0.12$).

*2.4. Data analysis*

Analyses were conducted in *RStudio* (Version 4.0.2; RStudio Team, 2015) and replicated the analytical approach of Boffo et al. (2018). Prior to hypothesis testing, baseline variables were screened for normality and univariate outliers. Preliminary analyses included a baseline group difference assessment (i.e., moderate-to high-risk vs non-problem; see Table 1), assessment of baseline approach bias scores via mixed analysis of variance (ANOVA) with stimulus category as the within- and group as the between-subject factors, and Spearman correlation coefficients computed between the G-TLFB indices and gambling approach bias scores at both baseline and follow-up time-points. The primary analysis implemented four stepwise hierarchical regressions assessing the predictive utility of baseline gambling approach bias on dependent variables at the 6-month follow-up (i.e., gambling frequency, duration, expenditure and PGSI score) over and above control variables (baseline scores for the PGSI, gambling frequency, duration, expenditure, and neutral approach bias entered as predictors in step 1; baseline gambling approach bias score entered in step 2).

In addition to the frequentist analyses, inverted Bayes factors ($BF_{10}$) were used to evaluate the likelihood of the data under the alternative hypothesis, compared to the null (Jarosz & Wiley, 2014). Uninformative default priors of *JASP* (Version 0.16; JASP, 2021) were used and a model including the gambling approach bias factor was compared to both a null model and a model including control variables only, as specified in step 1 described above. The Bayesian inclusion factor is reported ($BF_{\text{Inclusion}}$; Clyde et al., 2011) as the metric of interest, which quantifies the evidence for how much more the observed data are probable under models that include gambling approach bias as a predictor relative to the models that do not (Bergh et al., 2021).

Finally, a follow-up analysis was conducted combining the current data with the Dutch sample of Boffo et al. (2018). All abovementioned analyses were repeated but with the inclusion country of recruitment (i.e., Canada vs Netherlands) as a covariate within the ANOVA's (i.e., ANCOVA) and as an additional predictor within the regression models.

## 3. Results

*3.1. Group difference in gambling approach bias*

Results of the mixed ANOVA assessing baseline approach bias scores revealed no statistically significant main effects of stimulus category ($F_{(1,43)} = 0.49$, $P = 0.49$, $\eta^2_P = 0.01$) or group ($F_{(1,43)} = 0.77$, $P = 0.38$, $\eta^2_P = 0.02$). Further, no stimulus category × group interaction was observed ($F_{(1,43)} = 1.22$, $P = 0.26$, $\eta^2_P = 0.03$). Both moderate-to-high-risk gamblers and non-problem gamblers did not exhibit a differential approach bias towards gambling stimuli relative to neutral stimuli [moderate-to-high-risk gamblers: mean difference = 5.64, 95% CI mean difference = (-18.47, 29.76), $t_{(26)} = 0.48$, $P = 0.63$, $d = 0.06$; non-problem gamblers: mean difference = -19.25, 95% CI mean difference = (-40.86, 2.31), $t_{(25)} = -1.83$, $P = 0.08$, $d = -0.45$].[2]

*3.2. Correlation analysis*

Correlation analyses presented in Table 2 showed no significant associations between gambling approach bias and any indices of gambling behaviour (i.e., frequency, duration, or expenditure) at either time point.

## 4. Hierarchical regression analyses

Baseline gambling approach bias did not significantly predict any gambling outcome at 6-month follow-up (i.e., frequency, duration, expenditure, or PGSI score; Table 3) over and above control variables. These null findings were supported by inspection of the $BF_{\text{Inclusion}}$ for each dependent variable, respectively (see Table 3). For gambling duration, the data only marginally increased prior odds in favour of models including the gambling approach bias predictor (i.e., non-substantial evidence for inclusion). Further, for the models of gambling frequency and expenditure, and PGSI score, the data had in fact *decreased* the prior odds for including gambling approach bias as a predictor. This means that the data supported excluding the predictor gambling approach bias from the respective models, but, again, the evidence was non-substantial.

*4.1. Follow-Up analysis*

In re-running all aforementioned analyses combining the Canadian and Dutch samples, (1) moderate-to-high-risk gamblers (vs non-problem gamblers) did not exhibit differential approach bias responding towards gambling cues and (2) baseline gambling approach bias did not significantly predict any gambling outcome at 6-month follow-up. Notably, nationality was not a significant predictor (see supporting information; Appendix C and Appendix D Table 1A for further details).

Finally, post-hoc sensitivity analyses estimating the minimum effect size that could be examined under the power of the main study sample (i.e., Canadian alone) revealed only medium-to-large effect sizes were possible to detect (Cohen's $f^2 = 0.22$). However, for the combined sample (i.e., Canadian and Dutch together) small-to-medium effects

[2] Such findings also held at 6-month follow-up: no statistically significant main effects of stimulus category ($F_{(1,41)} = 0.09$, $P = 0.76$, $\eta^2_P = 0.01$) or group ($F_{(1,41)} = 0.24$, $P = 0.63$, $\eta^2_P = 0.002$) and no stimulus category × group interaction ($F_{(1,43)} = 1.24$, $P = 0.27$, $\eta^2_P = 0.03$) were observed.

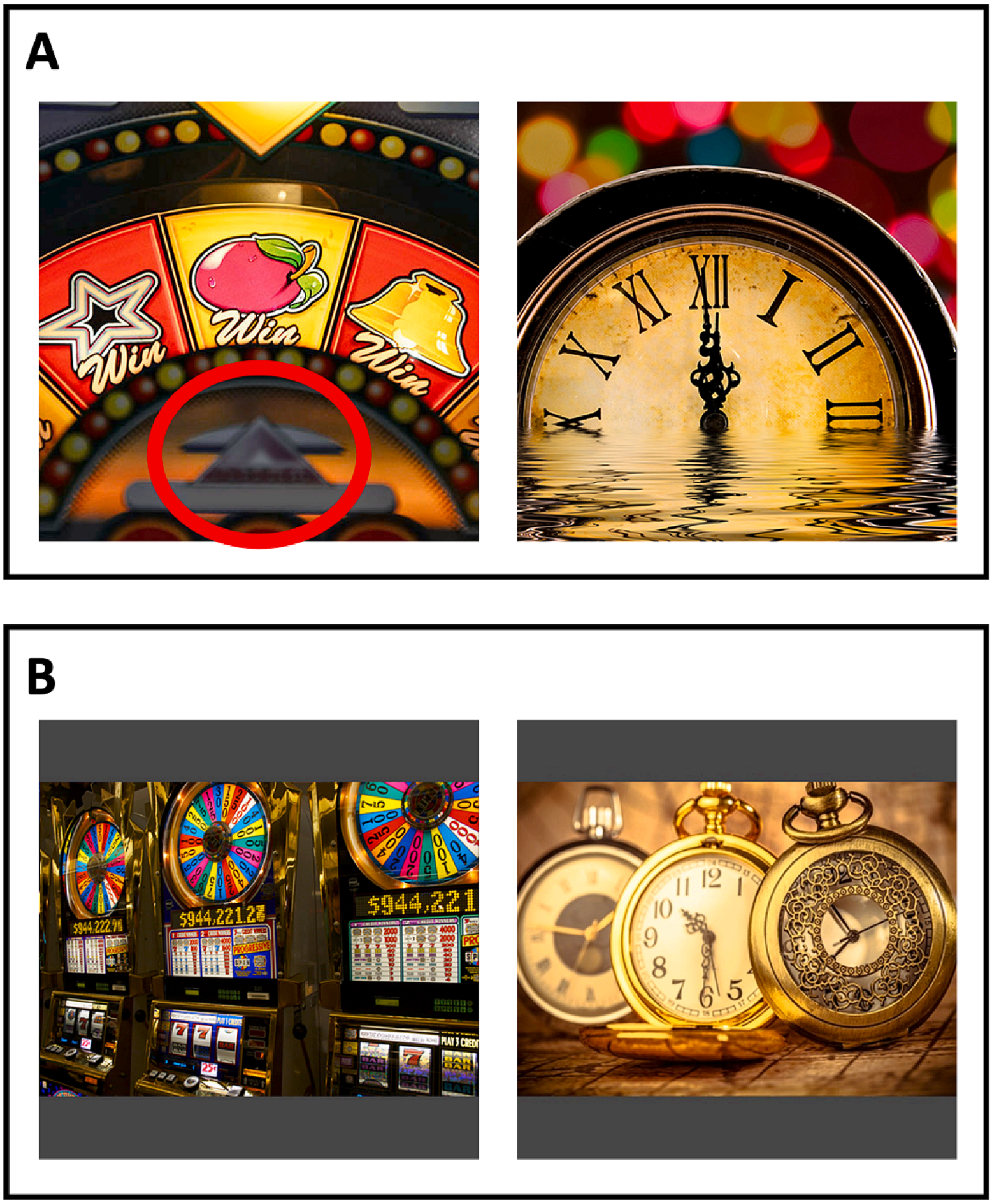


**Fig. 1.** An example figure of the experimental stimuli used in the G-AAT with the gambling stimuli on the left and the matched control image on the right (i.e., A = stimuli used in the Canadian arm of the initial multi lab study [20], with photoshopped alteration circled in red; B = stimuli used in the current replication).

could be detected (Cohen's $f^2 = 0.12$).

## 5. Discussion

The current study aimed to directly replicate Boffo et al. (2018) utilising the gambling-adapted approach avoidance task (G-AAT). To the best of our knowledge, this study represents only the second investigation to examine approach bias towards gambling cues in non-treatment-seeking gamblers with moderate-to-high severity of gambling problems, compared to a non-problematic gambler control group. However, the current study partially failed to replicate previous findings of the Dutch sample in this Canadian sample. Specifically, moderate-to-high-risk Canadian gamblers did not exhibit a greater tendency to approach gambling-related stimuli as opposed to neutral stimuli relative to non-problematic gamblers. Moreover, gambling approach bias was not predictive of prospective gambling behaviour across all TLFB indices, nor of severity of gambling problems (over-and-above control variables). These latter findings partially replicate the null findings of Boffo et al. (2018) for both the PGSI and expenditure outcomes. Taken together, these results suggest that, under the current paradigm, approach bias is not a useful predictor or explanatory factor for problem gambling severity, while evidence is mixed regarding its contribution to gambling behaviour across the two samples. Potential explanations for null findings will be discussed in consideration of the current study's limitations.

In contrast to the initial study attempt (Salmon et al., 2016), no evidence of an avoidance bias specific to moderate-to-high risk gamblers was observed. Yet, despite efforts to improve the task stimuli relevance from a cultural perspective, failure to capture individual gambling modality preference constitutes an important limitation. Research has shown that gamblers who play online vs land-based represent two uniquely distinct groups (Blaszczynski et al., 2016); such gambling modality preferences (i.e., online vs land-based) were not measured, nor were stimuli matched for modality on top of preferred activity (i.e., each

**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 | 0.03 | 43 | 0.83 | (-0.28, 0.35) |
| G-TLFB duration | 0.02 | 43 | 0.89 | (-0.29, 0.29) |
| G-TLFB expenditure | −0.21 | 43 | 0.18 | (-0.49, 0.07) |
| Six-month Follow-up | | | | |
| G-TLFB frequency | 0.14 | 39 | 0.37 | (-0.18, 0.43) |
| G-TLFB duration | 0.10 | 39 | 0.52 | (-0.22, 0.43) |
| G-TLFB expenditure | −0.01 | 39 | 0.93 | (-0.35, 0.31) |

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 follow back.

stimulus category included a mix of cues for both modalities). The recruitment methods may have introduced a sampling bias, likely affecting the Canadian cohort more significantly than the Dutch sample of Boffo et al. (2018). Canadian recruitment strategies primarily relied on land-based approaches (e.g., flyers near casinos), while the Dutch sample was recruited online. Thus, the Canadian sample may have included a greater proportion of land-based gamblers, whereas the opposite likely occurred for the Dutch sample. This difference in recruitment methods may partially account for the divergent findings.

Under such reflections, the online task format (including the stimuli presented) could be considered less appropriate for capturing an approach bias towards gambling in land-based gamblers. The online task format may have resulted in the stimuli being less motivationally salient in successfully replicating the gambling environment that would trigger an approach response for land-based players. Furthermore, the task stimuli contained online and land-based gambling activity cues within each gambling modality preference category. Therefore, dependent on the participant's preferences and the random stimulus pair selection, a proportion of the stimuli may not have sufficiently elicited an approach response towards the particular gambling cue in the image. Notably, tailoring stimuli to individual preferences has been found to enhance the detection of approach bias tendencies in smokers and food averse individuals (Waters et al., 2003; Lawrence et al., 2015).

Furthermore, the current study did not account for the association between gambling preferences and gambling motives (Sundqvist, Jonsson, & Wennberg, 2016; Flack & Stevens, 2019). Placing approach tendencies within a framework that also accounts for the role of motivation and self-regulation in addictive behaviours has been suggested (Köpetz et al, 2013). In the case of gambling, evidence suggests that gambling motives vary and are related to preferred gambling activities (Barrada et al, 2019). For example, electronic gambling machine players seem to gamble to cope with negative emotions by inducing physiological arousal, while slot machine gamblers gamble for the excitement of financial rewards. Under a more integrated approach, motives and mood states are thought to interact with preferred gambling activities influencing automatic cognitions, such as approach bias (Birch, Stewart & Zack, 2006). Therefore, experimentally manipulating or controlling for gambler motivation may be required when examining approach bias towards a particular gambling preference.

Collectively, the online task format, the variability in stimulus relevance, and the lack of a more nuanced understanding of gambling motives, may have contributed to the poor task reliability overall. While the internal reliability of the G-AAT in the Canadian sample was acceptable for a reaction-time based measure, it should be noted that when compared to traditional cut-off standards for self-report measures, it is relatively low, particularly for gambling-related stimuli, suggesting the presence of measurement error in the data. Of note, internal and test–retest reliability of the G-AAT task in Boffo et al. (2018) were even

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

| | Hierarchical Regression Step 1 | | | Hierarchical Regression Step 2 | | | Bayesian Analysis |
|---|---|---|---|---|---|---|---|
| *Predictors* | *B* | *SE B* | *β* | *B* | *SE B* | *β* | $BF^a_{Inclusion}$ $BF^b_{Exclusion}$ |
| **Outcome: 6-month G-TLFB Frequency (No. days gambled)** | | | | | | | |
| Baseline G-TLFB frequency | 0.627 | 0.108 | 0.702*** | 0.614 | 0.116 | 0.688*** | |
| Baseline neutral approach bias | 0.008 | 0.009 | 0.108 | 0.006 | 0.11 | 0.08 | |
| Baseline gambling approach bias | | | | 0.005 | 0.012 | 0.054 | $2.39^b$ |
| Model statistics | $F(2, 35) = 16.7, p < 0.001, R^2 = 0.488, R^2_{Adjusted} = 0.459$ | | | $(F(3, 34) = 10.9, p < 0.001, R^2 = 0.49, R^2_{Adjusted} = 0.445$ | | | |
| Model comparison | $\Delta\ F(1,34) = 0.13, p = 0.72, \Delta\ R^2 = 0.002$ | | | | | | |
| **Outcome: 6-month G-TLFB Duration** | | | | | | | |
| Baseline G-TLFB duration | 0.536 | 0.274 | 0.275 | 0.491 | 0.268 | 0.253*** | |
| Baseline neutral approach bias | 10.436 | 2.929 | 0.501** | 6.802 | 3.586 | 0.326 | |
| Baseline gambling approach bias | | | | 6.425 | 3.838 | 0.289 | $3.05^a$ |
| Model statistics | $F(2, 34) = 8.321, p = 0.001, R^2 = 0.328, R^2_{Adjusted} = 0.289$ | | | $F(3, 33) = 6.776, p = 0.001, R^2 =. 381, R^2_{Adjusted} = 0.325$ | | | |
| Model comparison | $\Delta\ F(1,33) = 2.804, p = 0.104, \Delta\ R^2 = 0.053$ | | | | | | |
| **Outcome: 6-month G-TLFB Expenditure** | | | | | | | |
| Baseline G-TLFB expenditure | 0.913 | 0.228 | 0.579*** | 0.930 | 0.228 | 0.590*** | |
| Baseline neutral approach bias | −0.073 | 1.619 | −0.007 | −0.999 | 1.799 | −0.089 | |
| Baseline gambling approach bias | | | | 2.123 | 1.835 | 0.186 | $1.35^b$ |
| Model statistics | $F(2, 32) = 8.108, p = 0.002, R^2 = 0.336, R^2_{Adjusted} = 0.295$ | | | $F(3, 31) = 5.909, p = 0.003, R^2 = 0.364, R^2_{Adjusted} = 0.302$ | | | |
| Model comparison | $\Delta\ F(1,31) = 1.339, p = 0.256, \Delta\ R^2 = 0.028$ | | | | | | |
| **Outcome: 6-month PGSI** | | | | | | | |
| Baseline PGSI | 0.825 | 0.172 | 0.643*** | 0.864 | 0.17 | 0.673*** | |
| Baseline neutral approach bias | −0.001 | 0.01 | −0.012 | 0.012 | 0.013 | 0.156 | |
| Baseline gambling approach bias | | | | −0.019 | 0.013 | −0.259 | $1.17^b$ |
| Model statistics | $F(2, 33) = 11.68, p < 0.001, R^2 = 0.414, R^2_{Adjusted} = 0.379$ | | | $F(3, 32) = 8.839, p < 0.001, R^2 = 0.453, R^2_{Adjusted} = 0.402$ | | | |
| Model comparison | $\Delta\ F(1,31) = 1.339, p = 0.256, \Delta\ R^2 = 0.028$ | | | | | | |

**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. $BF_{Exclusion} = BF_{Inclusion}$ values > 1, calculated as 1/ $BF_{Inclusion}$.

lower (i.e., ρ = (0.18, 0.42)). Concerns surrounding low reliability of the AAT have been evidenced across the literature (e.g., Kersbergen, Woud, & Field, 2015; Wittekind, Schiebel, & Kühn, 2023), as have concerns about limited convergent validity with other measures of approach bias and limited predictive validity for actual behaviour, suggesting the need to identify different measures of approach bias with superior psychometric properties.

Future research should elucidate the impact of gambling modality and game preference in the assessment of approach bias, presenting stimuli tailored to preferred gambling activities *and* modality. In this way, modality could be considered as a covariate to control for online vs land-based player preference effects. Furthermore, purposive sampling could be used to cluster gamblers based on gambling motives in relation to gambling preferences, to improve the homogeneity of gambler subgroups and explicitly considering factors contributing to gambler preferences and affecting the measurement properties of the AAT.

The small sample size of the Canadian cohort should also be acknowledged. Gambling stigmatization can hinder gamblers' willingness to participate, and ethical concerns often prevent financial compensation for their participation, leading to reduced inclusion (Dobbie et al., 2018; Cantinotti et al., 2016). These challenges have been acknowledged in the literature (Blaszczynski, Ladouceur, & Shaffer, 2004; Williams et al., 2010) and, as such, the current study attempted to address issues concerning study power by performing a follow-up analysis on a combined sample (i.e., Canadian and Dutch). Results showed no evidence of moderate-to-high-risk gamblers exhibiting differential approach tendencies towards gambling stimuli, aligned with results on the Canadian sample alone. Moreover, country of recruitment did not significantly predict differential approach bias on gambling outcomes. However, such findings should be considered with caution. The power analysis from the initial multi-lab study derived a minimum sample size capable of detecting a medium effect. By splitting the samples, the results within each cohort may be distorted by random and systematic error (Type 2). As such, the follow-up analysis may be considered a better-powered examination of approach bias tendencies in gamblers to date. Still, the power to truly examine cross-cultural differences even in the combined sample remains compromised. To solidify our findings, the current study and that of Boffo et al. (2018) should again be replicated.

Finally, a refinement of the study protocol is warranted as both studies' findings indicate a lack of evidence supporting the predictive value of approach bias for problem gambling severity and behaviour. This raises questions about the relative strength of approach tendencies compared to other factors, such as implicit memory associations or enhanced attentional processing, which have been more consistently associated with problematic gambling behaviour (Gainsbury et al., 2017; Stiles et al., 2016). Therefore, it is crucial to critically evaluate the approach bias assessment protocol, including stimuli modality and task reliability, as well as to consider factors such as sample size, statistical power, and cultural influences. Only through such rigorous scrutiny we can draw meaningful conclusions about the mechanistic relevance of approach bias in the onset and maintenance of problem gambling, as well as its potential utility as a target for treatment.

### 5.1. Conclusion

In summary, this study did not replicate, in a Canadian sample, the findings of Boffo et al. (2018) that moderate-to-high-risk Dutch gamblers exhibit a stronger tendency to approach rather than to avoid gambling-related cues compared to neutral ones. Moreover, approach bias did not predict gambling behaviour over time, again failing to replicate Boffo et al. (2018). We argue the importance of considering the heterogenous nature of the gambling population and environment, implying diversity in gambling modality preferences which are likely to affect reliability of bias assessment measures. Furthermore, the impact of cross-cultural differences remains unexplored and should be more explicitly examined in light of their potential influence on gambling behaviour. (Cowie et al., 2017). The significance of replication endeavours, such as the present study, cannot be overstated. The current investigation represents only the second attempt to examine approach-avoidance bias in gamblers. Considering the absence of replication in the Canadian sample, it is imperative to more systematically embed factors underlying gambling preferences in future work. Moreover, multiple, statistically-powered replications must be conducted prior to implementing cognitive bias re-training modules in individuals seeking treatment for gambling problems.

## Role of funding sources

The current research was funded by a grant received from The International Center for Responsible Gaming (ICRG; formerly known as the National Center for Responsible Gaming) awarded to Sherry H. Stewart, Reinout W. Wiers and Elske Salemink. All research in conjunction with the current paper and its content falls under the sole responsibility of the authors and does not necessarily represent the official views of the ICRG. The ICRG had no role in the study design, collection, analysis or interpretation of the data, writing the manuscript or the decision to submit the paper for publication. Research funded through the ICRG is accrued via multiple sources, including support from the gambling industry. However, no direct funding derived from the gambling industry has contributed to the current research. Dr. Stewart is supported through a Tier 1 Canada Research Chair in Addictions and Mental Health from the Canadian Institutes of Health Research.

**Ethics Approval:** The study was approved by the Health Sciences Research Ethics Board of Dalhousie University, Canada (REF2015-3508).

**Consent to Participate:** Informed consent was obtained from all individual participants included in the study.

**Consent for Publication:** All study participants were made aware that their data would be used for scientific publications in anonymized and aggregated format.

**Availability of Data and Material and Code Availability**: At the time of data collection participants did not consent to share their data open access; as such, anonymised data with no identifiable material (e.g., demographic information) will only be made available from the authors upon reasonable request.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

Data will be made available on request.

## Acknowledgments

The authors would like to give special thanks to Megan Cowie for her help in creating the culturally relevant Canadian stimuli utilised in the current protocol. Further, we would like to thank Bruno Boutin for his technical support in the set-up of the online study platform and assistance in preparation and wrangling of the task data.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.addbeh.2023.107778.

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