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Eye on the Prize: High-Risk Gamblers Show Sustained Selective Attention to Gambling Cues

Amanda Hudson,[1] Bunmi O. Olatunji,[2] Karen Gough,[3] Sunghwan Yi,[3] &
Sherry H. Stewart[1]

[1] Department of Psychology & Neuroscience, Dalhousie University, Halifax, NS, Canada
[2] Department of Psychology & Psychiatry, Vanderbilt University, Nashville, TN, USA
[3] Department of Marketing & Consumer Studies, University of Guelph, Guelph, ON, Canada

Abstract

Disordered gambling is characterized by persistent and problematic gambling, leading to impairment or distress, which may be exacerbated by vigilance to gambling cues in the environment. Yet, questions regarding the specific attentional biases present in gamblers remain unresolved. In the current study, we used a rapid serial visual presentation paradigm to examine attentional orienting and maintenance/disengagement for gambling stimuli, relative to emotional and neutral stimuli, in high- and low-risk gamblers ($N = 57$). High-risk gamblers showed attentional biases for gambling stimuli, relative to other distractors, and these biases were observed at the level of attentional maintenance/disengagement. Low-risk gamblers showed some evidence of non-specific attentional biases (to negative and gambling pictures). Low-risk, but not high-risk, gamblers demonstrated sustained biases for negative items and facilitated disengagement from positive items. Findings highlight differences in attentional processes between high- and low-risk gamblers and point to sustained biases as worthy targets for clinical interventions. Future work should assess the malleability of gambling biases in high-risk gamblers and determine whether altering attention to gambling items influences gambling behaviour.

Keywords: attentional bias, gambling

Résumé

Le jeu compulsif est caractérisé par des comportements liés au jeu qui sont problématiques et persistants, et qui entraînent une détresse ou une incapacité à fonctionner pouvant être exacerbées par l'attention accordée aux signaux associés au jeu dans

l'environnement. Pourtant, les questions relatives à la présence d'un biais attentionnel spécifique chez les joueurs demeurent sans réponses. La présente étude a utilisé un modèle de présentation visuelle sérielle rapide (Rapid Serial Visual Presentation [RSVP]) afin d'examiner l'orientation de l'attention et le maintien ou le décrochage de celle-ci en présence de stimuli liés au jeu par rapport à des stimuli neutres et chargés émotivement chez des joueurs à faible risque et à haut risque (N = 57). Un biais attentionnel pour les stimuli liés au jeu pouvant aller jusqu'au maintien ou au décrochage de l'attention a été observé chez les joueurs à haut risque, par rapport aux autres éléments de distraction. Les données sur les joueurs à faible risque indiquent quant à elles la présence d'un biais attentionnel non spécifique (pour les images de jeu et négatives). Un biais attentionnel soutenu pour les éléments négatifs facilitant le décrochage de l'attention à des éléments positifs a été observé chez les joueurs à faible risque, mais non chez ceux à haut risque. Les résultats de l'étude mettent d'une part en évidence les différences entre le processus attentionnel des joueurs à haut risque et celui des joueurs à faible risque, et indiquent d'autre part que les biais attentionnels soutenus peuvent constituer les cibles d'intervention cliniques efficaces. Une prochaine étude devra évaluer la malléabilité du biais attentionnel pour le jeu des joueurs à haut risque et déterminer si une modification de l'attention accordée aux éléments liés au jeu peut influencer les comportements associés au jeu.

Introduction

Disordered gambling is now recognized as a behavioural addiction in the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; American Psychiatric Association, 2013), and it shares many diagnostic criteria with substance use disorders. Gambling and substance use disorders may also share similar etiological processes. One such process may be an attentional bias, or enhanced processing of addiction-relevant or addiction-related cues. Using various attentional and electrophysiological measures, researchers have found that heavy drinkers, smokers, and other substance abusers demonstrate attentional biases for cues that they associate with their substance of abuse (Littel, Euser, Munafò, & Franken, 2012; Robbins & Ehrman, 2004, for reviews). Such biases are important topics of investigation considering the role they may play in the development and maintenance of substance use disorders (Field & Cox, 2008; Franken, Kroon, Wiers, & Jansen, 2000). For instance, a major meta-analysis by Field, Munafò, and Franken (2009) found that attentional bias for substance-related cues was associated with self-reported craving across substances. Relatedly, biases for alcohol cues have been associated with relapse following treatment in alcohol-dependent adults (Garland, Franken, & Howard, 2012).

Just as attentional biases have been studied in substance use disorders, research on attentional biases in gamblers has progressed in recent years (Zack & Poulos, 2006). Still, important questions remain unresolved. Boyer and Dickerson (2003) examined

attentional biases on a modified Stroop colour-naming task, comparing gamblers with high and low control over gambling on the basis of their scores on the Scale of Gambling Choices (Baron, Dickerson, & Blaszczynski, 1995). Low control gamblers displayed longer colour-naming times (i.e., attentional interference) for gambling-related words than they did for other word types (drug-related; neutral)—an effect that was not seen in the high control group. A similar study (McCusker & Gettings, 1997) examined Stroop colour-naming times for gambling, drug, and neutral words in self-identified compulsive gamblers and their spouses (who acted as a control group), exposing gambling-specific attentional biases in the compulsive gamblers. Although these studies provide insight into attentional biases in problem gamblers, they used word colour-naming times as the outcome. This may be problematic since stimulus effects on attentional processes may be confounded with effects on higher order semantic processes (Compton et al., 2003). To address this limitation, Molde et al. (2010) used a pictorial Stroop and again revealed attentional biases for gambling stimuli in slot machine gamblers with a diagnosis of pathological gambling relative to individuals with no history of gambling problems.

Much of the knowledge on the nature and function of attentional biases among pathological gamblers has been based on research with the Stroop. However, Stroop tasks are limited in that they often tap into reading, lexical decision, and colour-naming processes in addition to, or instead of, selective attention (Algom, Chajut, & Lev, 2004). Others argue that Stroop tasks can capture global biases for gambling stimuli, but do not differentiate between orienting (i.e., initial directing of attention) and later maintenance/disengagement (i.e., sustained allocation of attention and [in] ability to redirect attention; Fox, Russo, Bowles, & Dutton, 2001). In contrast, in visual dot probe tasks, transient and more sustained biases can be discerned if cue durations are manipulated appropriately. Using a visual probe task, Vizcaino et al. (2013) found that gamblers who met criteria for pathological gambling on the National Opinion Research Center DSM-IV Screen for Gambling Problems responded more quickly to dots cued by gambling-related stimuli than they did to non-gambling cues at exposure times that were indicative of a preferential attentional maintenance for gambling items. No differences in response times to gambling and non-gambling cued targets were seen in the control group of healthy volunteers. These findings mirror research on gamblers' Stroop performance, but with the added benefit of identifying the type of bias (i.e., attentional maintenance to gambling cues). However, dot probe tasks carry their own limitations, such as low internal reliability and poor short-term test-retest reliability (Schmukle, 2005). Furthermore, visual probe tasks assess attentional biases in terms of facilitated responding to cued locations, as opposed to impaired responding on other tasks following gambling-cue exposure; the latter may be more representative of the distracting, attention-consuming nature of gambling cues in real-world settings.

Other tasks have also been used to overcome the limitations of the Stroop. For example, Brevers, Cleeremens, Bechara et al et al. (2011) examined attentional bias for gambling and neutral stimuli in problem gamblers (from scores on the South Oaks Gambling Screen [SOGS]; Lesieur & Blume, 1987) and in non-problem

gamblers using the flicker paradigm, in which two images were repeatedly flashed on the screen and participants had to report a single difference (gambling or non-gambling item) between pictures. Using eye-tracking and response latencies, the authors found speeded orienting to and impaired disengagement from gambling items in the problem group relative to the non-problem group. This study is valuable in that it delineates the attentional processes involved in the problem gamblers' bias. However, interpretations are limited by the restricted set of comparison stimuli and by the task of attending to items, rather than ignoring them. The latter might be more representative of strategies used to avoid gambling triggers in the real world.

One measure that has the potential to assess the distracting value of gambling-pertinent stimuli, while also distinguishing between types of attentional biases, is the rapid serial visual presentation (RSVP) paradigm. Brevers, Cleeremens, Tibboel et al. (2011) had problem gambler and control participants view gambling and neutral target words that were embedded in a rapid stream of distractor words in an RSVP task. At the end of each trial, gamblers were required to report the target words that appeared among distractors. Problem gamblers were more accurate in reporting gambling targets than in reporting neutral targets, indicating enhanced processing of gambling stimuli in those experiencing gambling problems. Performance for gambling and neutral targets was not significantly different in controls. Although Brevers, Cleeremens, Tibboel et al. provided insight into the attentional biases of problem gamblers, stimulus sets were limited to gambling and neutral items. Delineation of the relative magnitude of gambling biases requires additional categories of comparison stimuli. In addition, Brevers, Cleeremens, Tibboel et al. (2011) applied gambling words as targets, as opposed to pictorial distractors, once more limiting the ability to interpret findings in terms of the attentionally distracting nature of gambling cues.

Together, the aforementioned studies help elucidate gambling-related attentional biases that distinguish problem and non-problem gamblers.[1] However, there remains a need for further work to pinpoint the attentional processes involved in these biases and to establish whether such biases exceed those typically displayed for emotional cues. To address these limitations of previous research, we assessed attentional biases in high- versus low-risk gamblers on a cognitive task that operationalizes components of attention (orienting vs. disengagement), using neutral pictures as a baseline, as well as benchmark "distractors" (i.e., emotional pictures) and gambling pictures. Emotional stimuli preferentially capture and hold attention, relative to neutral items, making positive and negative emotional pictures appropriate comparison distractors (Most, Chun, Widders, & Zald, 2005; Vuilleumier, 2005). Moreover, including emotional items as distractors addresses the question of whether high-risk gamblers have a general bias to attend to emotionally salient stimuli (including gambling-relevant cues), or a selective attentional bias for gambling cues (per Bauer & Cox, 1998; Robbins & Ehrman, 2004). More precisely, in the current study, high- and low-risk

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[1]Cross-study comparisons may be limited by the varied nature of study groups in studies on attentional biases in problem gamblers and controls.

gamblers completed the RSVP task (Most et al., 2005; Olatunji, Ciesielski, & Zald, 2011), in which rotated targets were presented at either 200-ms or 800-ms lags following distractors, permitting an assessment of attentional orienting (200-ms lag) and disengagement (800-ms lag). To elaborate, performance on the short-lag trials reflects the level of initial attentional allocation to the distractor (orienting bias). If participants categorize the target inaccurately, presumably their attention was devoted to early processing of the distractor. Performance on the long-lag trials reflects the amount of sustained attentional engagement (or, conversely, disengagement) with the distractor. If participants categorize the target inaccurately, presumably their attentional resources were not recovered to attend to the target.

High-risk gamblers were expected to show attentional biases for gambling stimuli, relative to all other stimuli, including emotional stimuli, on the basis of attentional bias research in substance (ab)users (e.g., Bauer & Cox, 1998; Lubman, Allen, Peters, & Deakin, 2008; Robbins & Ehrman, 2004). Gambling-specific biases were not anticipated in low-risk gamblers. From prior research with other clinical populations, biases were predicted to be most prominent at the level of attentional maintenance/disengagement effects (i.e., at the 800-ms lag; Koster, De Raedt, Goeleven, Franck, & Crombez, 2005; Olatunji et al., 2011; Vizcaino et al., 2013). Moreover, sustained, as opposed to initial, biases to gambling stimuli were expected to characterize high-risk gamblers given that attentional maintenance of gambling cues should theoretically be more problematic than transient bias, in which attentional resources are quickly recovered. In both groups, biases for emotional stimuli (in particular, negative stimuli; Vuilleumier, 2005) were expected to occur relative to neutral stimuli.

Method

Participants

Participants were 57 regular gamblers (35 males and 22 females) from 19 to 80 years of age (M = 45.19, SD = 19.24). Sixty-one percent of participants were White, 14% were Native Canadian/First Nations, 8% were Black, 5% were South Asian, and the remainder identified as other. The majority (62%) of participants indicated having an annual personal income of less than $40,000 Cdn. Participants were recruited to fill two groups: a high-risk group and a low-risk control group. Twenty-six participants were included in the low-risk gambling group (on the basis of Problem Gambling Severity Index scores indicating non-problem/low-risk gambling), and the remainder (n = 31) were included in the high-risk gambling group (on the basis of Problem Gambling Severity Index scores signifying moderate risk to problem gambling). Participants were recruited from the undergraduate student body at two Canadian universities, as well as from the surrounding communities. Inclusion criteria consisted of having gambled at least three times in the last 2 months in a casino, by using electronic gambling machines (EGMs), or by using online gambling (Yi, Stewart, Collins, & Stewart, 2015); being 19 years of age or older; and speaking English as a native language. Individuals were excluded if they were attempting to quit gambling or were receiving treatment for problem gambling. Participants were screened over

Table 1

Group Distributions for Study Site and Sex, and Means and Standard Deviations for Gambling Severity, Gambling Frequency, and Age of Participants in High- and Low-Risk Gambling Groups

Demographics and gambling statistics	High risk (*SD*)	Low risk (*SD*)
Age	42.74 years (19.29)	48.12 years (19.14)
CPGI (gambling severity)	7.45 (4.26)	1.04 (0.82)
Gambling frequency[a]	10.21 (9.24)	5.48 (5.87)
Sex	10 females, 21 males	12 females, 14 males
Study site	18 Site 1, 13 Site 2	11 Site 1, 15 Site 2

Note. CPGI = Canadian Problem Gambling Index. There were no significant group differences in age, sex, or study site recruitment (all $ps > .20$). Participants in the high-risk group gambled significantly more frequently than did those in the low-risk group ($p = .04$). Gambling severity scores were significantly higher in the high-risk group than they were in the low-risk group ($p = .001$).

[a] Number of times gambled in last 2 months.

the telephone to ensure eligibility. See Table 1 for demographic information and gambling descriptive statistics (frequency and severity) for participants in the high- and low-risk groups.

Procedure

After providing informed consent, participants completed several self-report and cognitive measures, only two of which are relevant to the current study and are described herein. Upon study completion, participants were debriefed and provided with $20 as compensation. All participants were provided with contact information for the local addictions services and the problem gambling helpline.

Measures

Canadian Problem Gambling Index (CPGI). The nine-item Problem Gambling Severity Index (PGSI) scale of the CPGI (Ferris & Wynne, 2001) was used to assess the presence and severity of problem gambling. Participants rate the frequency at which they have engaged in the behaviour or experienced the given consequence in the last 12 months on a scale from 0 (*never*) to 3 (*almost always*). The PGSI shows good validity (i.e., content, construct, and criterion-related), good internal consistency ($\alpha = .84$), and adequate test-retest reliability at intervals of 3 to 4 weeks ($r = .78$; Ferris & Wynne, 2001). Participants who met criteria for non-problem or low-risk gambling (PGSI total scores = 0 to 2) were included in the low-risk group ($M = 1.04$, $SD = .82$), whereas those meeting criteria for moderate risk to problem gambling (PGSI = 3+) were included in the high-risk group ($M = 7.45$, $SD = 4.26$) to match the two-group design of previous attentional bias research (Baron et al., 1995; McCusker & Gettings, 1997). Adjacent risk groups were combined on the basis of previous research by using the PGSI (Ellery, 2008) and other measures of gambling severity (i.e., SOGS; Brevers, Cleeremans, Tibboel et al., 2011).

Rapid serial visual presentation (RSVP) task.   This task was based on the standard attentional blink paradigm (Most et al., 2005) and was used to assess attentional biases for gambling-related stimuli. Participants searched for target items (horizontally rotated landscapes) within a rapid series of pictures, which they had to identify as being rotated or upright and as being rotated to the left or to the right (when rotated). Most of the targets (96%) were rotated. Distractor pictures preceded the rotated targets by either 200 or 800 ms and fell into the following categories: (a) gambling, (b) neutral, (c) negative, and (d) positive. See Appendix A for examples of each category of distractor. Emotional pictures (in particular, negative) were selected to provide a distracting benchmark against which gambling distractor trials could be compared (Vuilleumier, 2005). In addition, because the distracting effects of these images are generalizable (i.e., not gambling specific), they provided a reference point to establish the magnitude and specificity of biases for gambling stimuli. The neutral pictures provided a baseline comparison. Fillers (upright landscapes), distractors (gambling, neutral, negative, and positive pictures), and targets (rotated landscapes) were each presented for 100 ms. Each trial included 17 images, including one distractor, one target, and 15 fillers. At the end of each trial, participants were asked to indicate, by key press, if they saw a rotated image (yes, no) and, if yes, which direction it was rotated (right, left). Participants were told that the accuracy of their responses would be recorded. Participants completed 16 practice trials and 168 randomized test trials (42 for each category of distractor). See Appendix B for an example of trial events. This protocol is similar to that of Olatunji et al. (2011). The RSVP paradigm was programmed and presented by using Direct RT software (Empirisoft Corporation, NY). Split-half reliabilities comparing first and second halves for the 200- and 800-ms lag trials were .69 and .78 for positive distractor trials, .88 and .80 for negative distractor trials, .84 and .82 for neutral distractor trials, and .78 and .88 for gambling distractor trials, indicating acceptable to good internal consistency for the task.[2]

Neutral, negative, and positive pictures for the RSVP task were selected from the International Affective Pictures System (IAPS; Lang, Bradley, & Cuthbert, 2005). Normative data for picture ratings were gathered by Lang et al. and can be accessed through the IAPS. Specifically, valence ratings range from 1 (*unpleasant*) to 9 (*pleasant*) and arousal ratings range from 1 (*relaxing/unarousing*) to 9 (*arousing*). The mean IAPS valence ratings for the 42 negative, neutral, and positive pictures included as distractors in the RSVP task were 3.03 (0.81), 5.02 (0.33), and 7.29 (0.63), respectively. Arousal ratings were 5.77 (0.77), 3.08 (0.66), and 4.82 (0.74) for negative, neutral, and positive pictures, respectively. In addition to recording ratings from the IAPS manual, we also collected ratings for each of these images from our sample of gamblers, using an adapted (5-point) self-assessment manikin (Lang et al., 2005). Mean valence ratings for negative, neutral, and positive pictures were 2.10 (.71), 3.16 (.62), and 4.16 (.72), respectively, and corresponding arousal ratings were 2.62 (1.07), 1.65 (.58), and 2.32 (.91), respectively.

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[2]Accuracy was used, as opposed to response times, as participants were instructed to respond accurately, but were not given instructions regarding response speeds. In addition, there is some concern that response time data, in general, are not as useful as accuracy in measuring attention (Armstrong & Olatunji, 2012).

Gambling pictures were collected from publicly available sources and consisted of scenes from casinos, card games, EGMs, and generic online gambling screens. Participants also provided ratings for each of the gambling images ($M_{Valence}$ = 4.06, $SD_{Valence}$ = .78; $M_{Arousal}$ = 2.46, $SD_{Arousal}$ = 1.18) at the same time that they rated the other stimuli. A 2 (group) by 4 (distractor type) mixed measures analysis of variance (ANOVA) revealed no main effect of group on valence ratings (p = .97) and no group by distractor type interaction (p = .75). Likewise, overall arousal ratings did not differ by group (p = .35), and no group by distractor interaction was observed (p = .58). However, there were main effects of distractor type.[3]

Data Analysis

Mixed measures ANOVAs were conducted, with distractor type (negative, neutral, positive, gambling) and lag (200 ms, 800 ms) as the within-subjects variables and problem gambling group (high-risk, low-risk) as the between-subjects variable. Separate ANOVAs were conducted for two different dependent measures: accuracy and disengagement efficiency. Trials in which participants responded correctly to both the detection (yes/no) and direction (right/left) questions were deemed accurate and awarded a score of 1. Otherwise, trials were scored as inaccurate (0). Mean accuracy (ranging from 0 to 1) was tabulated for the various combinations of distractor type (i.e., gambling, positive, negative, control) and time lag (i.e., 200 vs. 800 ms). Disengagement efficiency scores were computed by subtracting accuracy on 200-ms lag trials from accuracy on 800-ms lag trials, which provided a measure of disengagement and accounted for initial orienting (per Olatunji et al., 2011). Complete RSVP task data were available for all participants.

Results

Accuracy

A 4 (distractor type) by 2 (time lag) by 2 (risk group) mixed measures ANOVA on accuracy revealed a significant main effect of distractor type, $F(3, 165)$ = 13.87, Mean Squared Error (MSE) = .01, p = .001, partial η^2 = .20. Overall, target responses were most accurate when they were preceded by positive distractors (M = .56, SD = .25), compared with any other distractor type ($M_{negative}$ = .49, $SD_{negative}$ = .22, $M_{neutral}$ = .50, $SD_{neutral}$ = .23, $M_{gambling}$ = .48, $SD_{gambling}$ = .21), p = .001 for all comparisons. There were no differences between neutral, negative, and gambling distractor trials (all ps > .10). A significant main effect of time lag also emerged, $F(1, 55)$ = 73.32, MSE = .04, p = .001, partial η^2 = .57. As in previous work

[3]Pairwise comparisons revealed that positive and gambling pictures were rated as most positive (all ps < .001), and negative pictures were rated as most negative (all ps < .001). There were no differences between positive and gambling valence ratings (p = .37). Negative pictures were more arousing than positive or neutral pictures (ps < .05), but were not more arousing than gambling pictures (p = .31). Gambling pictures were more arousing than neutral pictures (p = .001), but were not more arousing than positive pictures (p = .21). High- and low-risk gamblers' valence and arousal ratings were not significantly different for any of the distractor types (all ps > .10).

(Olatunji et al., 2011), we observed higher accuracy for targets appearing 800 ms after distractors ($M = .59$, $SD = .27$) than for targets appearing 200 ms after distractors ($M = .42$, $SD = .18$). There was also a significant distractor by lag interaction, $F(3, 165) = 7.25$, MSE = .01, $p = .001$, partial $\eta^2 = .12$, subsumed within a marginal distractor by lag by risk group interaction, $F(3, 165) = 2.51$, MSE = .01, $p = .06$, partial $\eta^2 = .04$.[4]

This three-way interaction was followed up with a set of 4 (distractor type) by 2 (time lag) repeated measures ANOVAs for high- and low-risk gamblers separately. A significant two-way interaction between distractor type and lag was observed for both high- and low-risk gamblers (both $ps < .01$); thus, separate one-way repeated measures ANOVAs (with distractor type as the within-subjects variable) were conducted for the 200-ms and 800-ms lag trials for each group. At the 200-ms lag, no significant distractor type effects were observed for either high- or low-risk gamblers. However, at the 800-ms lag, accuracy was significantly affected by distractor type for both risk groups (both $ps < .001$). For high-risk gamblers, 800-ms lag target decisions were most accurate following positive distractors (relative to all other distractors, $ps \leqslant .05$), and target decisions following gambling distractors were least accurate (compared with all other distractors, $ps \leqslant .001$). There was no difference in accuracy between neutral and negative trial targets. Low-risk gamblers were most accurate in responding to 800-ms lag targets following positive distractors (compared with all other distractor types, $ps < .01$). Accuracy for targets following negative and gambling distractors was equally poor and was significantly worse than for neutral or positive distractor trial targets ($ps < .05$). See Figure 1.

To determine whether accuracies were significantly different from chance for each gambler group, we conducted one-sample t tests, comparing accuracy for each trial type to chance accuracy (50%) for low- and high-risk gamblers separately. Accuracy for 200-ms lag targets was not significantly above chance for any distractor type for either low- or high-risk gamblers. For low-risk gamblers, 800-ms lag accuracy on positive trials was significantly above chance ($p = .004$), accuracy on neutral trials was marginally above chance ($p = .07$), and negative and gambling trial accuracies were at chance levels ($ps > .30$). For high-risk gamblers, only gambling trial accuracy was so low as to be comparable to chance performance ($p = .65$) on the 800-ms lag trials. Positive trials were significantly above chance ($p < .02$) and neutral and negative trials were marginally above chance ($ps \leqslant .08$). These findings mirror those of the absolute accuracy scores presented earlier.

Disengagement Efficiency Scores

A 4 (distractor type) by 2 (risk group) mixed measures ANOVA on disengagement efficiency scores exposed a significant main effect of distractor type, $F(3, 165) = 7.25$,

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[4]Relaxing alpha is acceptable when an interaction is predicted a priori and the pattern of means is consistent with predictions, given the increased power required to detect interactions relative to main effects (Winer, 1971).
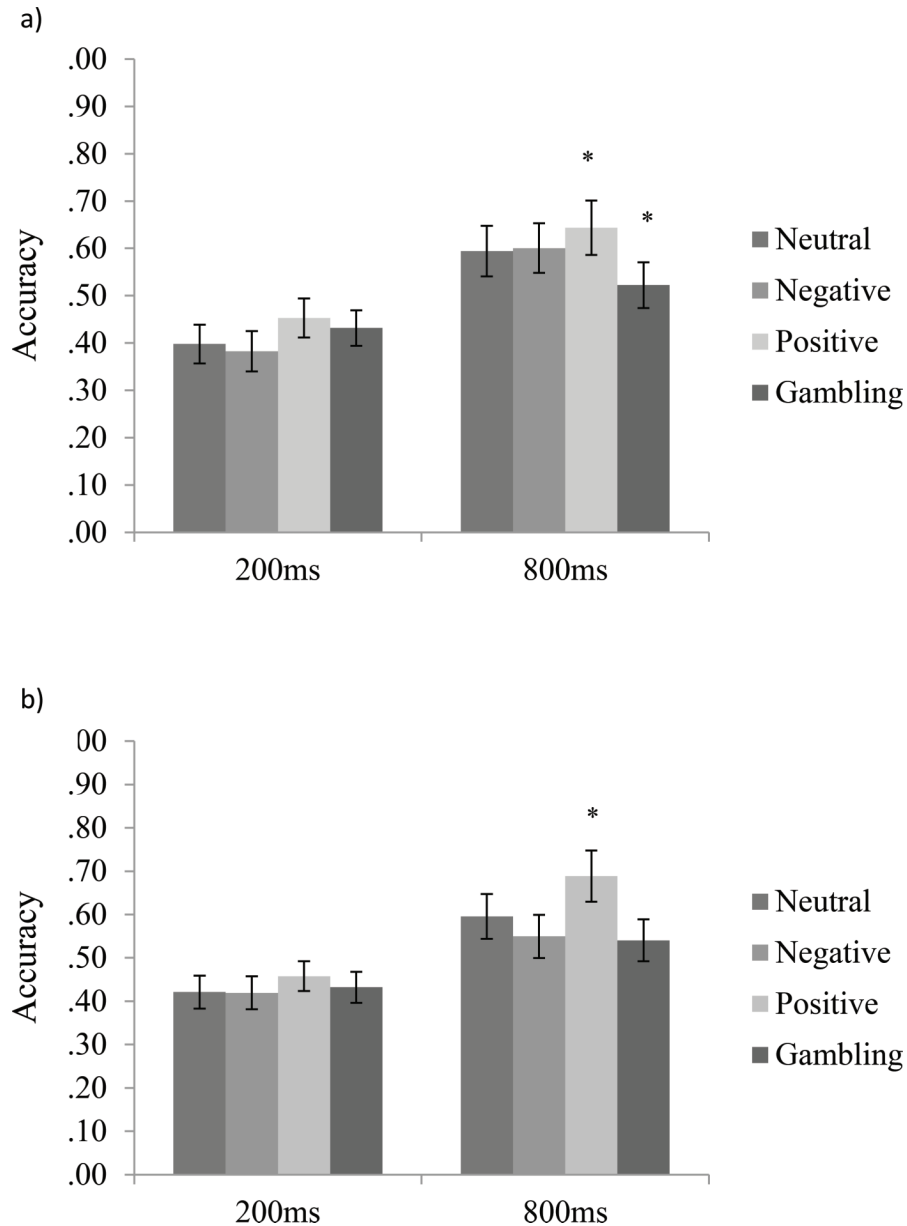
a)

b)

Figure 1. Accuracy scores for targets appearing after neutral, negative, positive, and gambling distractors at 200-ms and 800-ms time lags for (a) high-risk and (b) low-risk gamblers. No distractor type differences were observed at 200 ms for either risk group. At 800 ms, high-risk gamblers' target decisions were most accurate following positive distractors and were least accurate following gambling distractors. Low-risk gamblers were most accurate for targets following positive distractors. Accuracy for targets following negative and gambling distractors was significantly worse than for neutral or positive distractor trial targets.

MSE = .02, p = .001, partial η^2 = .12, as well as a marginal distractor by group interaction, $F(3, 165)$ = 2.51, MSE = .02, p = .06, partial η^2 = .04 (see Footnote 2). The interaction was decomposed by conducting separate one-way repeated measures
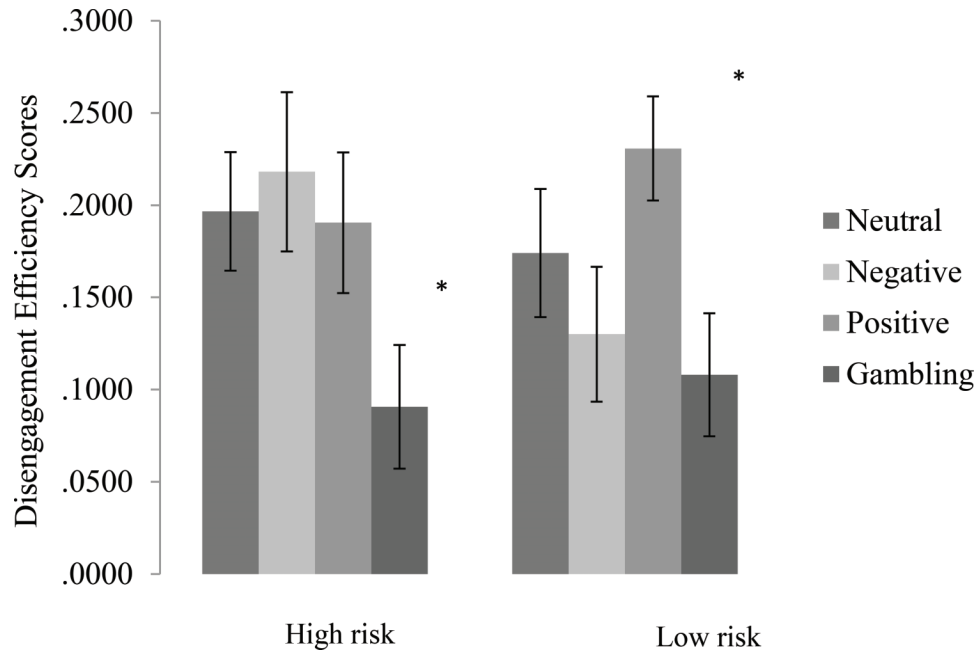
Figure 2. Disengagement efficiency scores (800ms lag accuracy subtract 200 ms lag accuracy) for high- and low-risk gamblers for all distractor types. High-risk gamblers showed poorer disengagement from gambling distractors than they did from all other distractors. Low-risk gamblers showed better disengagement from positive distractors than they did from all other distractors. No other significant differences were observed.

(distractor type) ANOVAs for high- and low-risk groups. For high-risk gamblers, there was a significant effect of distractor type, $p = .001$, with the poorest disengagement scores corresponding to gambling distractors, compared with all other distractor types (all $ps < .05$). No other significant differences were observed. A significant effect of distractor type was also observed among the low-risk gamblers, $p = .01$, revealing superior disengagement for positive distractors ($ps < .01$ for comparisons with negative and gambling distractors, $p = .07$ for positive-neutral comparison). See Figure 2.[5]

Discussion

The current study examined attentional biases for gambling stimuli, relative to emotional and neutral stimuli, in high-risk and low-risk gamblers. To do so, we used an RSVP paradigm, which decomposes different components of attention, namely, attentional orienting and maintenance/disengagement, by using different time lags between distractors and targets. As hypothesized, high-risk gamblers showed the poorest accuracy for targets that were preceded by gambling distractors compared

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[5]Although accuracy scores for the longer time lags and disengagement efficiency scores were correlated, they were not redundant. Correlations for accuracy at 800-ms lags and disengagement efficiency scores were .63, .65, .66, and .78 for negative, gambling, neutral, and positive trials, respectively.

with all other distractor types, and this effect was observed only at the longer time lags between distractors and targets (i.e., 800 ms). In fact, the accuracy for targets following gambling distractors on 800-ms lag trials was comparable to chance performance for high-risk gamblers, whereas performance was above chance for targets following the other distractor types. This finding suggests that high-risk gamblers were biased to maintain attention when presented with a gambling distractor and had difficulties disengaging from these items. This interpretation was also supported by the disengagement efficiency score results, whereby high-risk gamblers exhibited the poorest disengagement for gambling distractors, after accounting for initial orienting, relative to all other distractor types, suggesting that gambling pictures were uniquely captivating for this group.

By contrast, low-risk gamblers were equally inaccurate in responding to targets preceded by negative and gambling distractors at the 800-ms time lag (relative to positive and neutral distractors). Indeed, accuracy for targets preceded by both negative and gambling distractors was at chance-level performance. Furthermore, after accounting for initial orienting responses, we found that low-risk gamblers disengaged from gambling items as easily as they did from neutral and negative distractor types. Although high-risk gamblers exhibited a bias for maintaining attention on gambling stimuli that was specific (only for gambling distractors) and robust (detected across both measures of attentional disengagement), low-risk gamblers showed some preferential maintenance of attention to both negative and gambling items, but this maintenance of attention disappeared when initial orienting responses were taken into account.

Our finding that high-risk gamblers exhibit gambling-specific attentional biases corroborates previous work (Boyer & Dickerson, 2003; McCusker & Gettings, 1997; Vizcaino et al., 2013). In addition, it builds on prior work by pinpointing the attentional component involved in these biases (i.e., sustained attention rather than initial orienting) and by measuring the extent of these biases relative to established emotional distractors. Content-specific maintenance biases, such as those observed for gambling cues in our high-risk gambler group, have been found in other clinical phenomena (e.g., dysphoria, obsessive-compulsive disorder) for stimuli relevant to those particular conditions (Koster et al., 2005; Olatunji et al., 2011). It makes sense that clinically meaningful biases be tied to later stages of processing, as earlier attentional biases are more fleeting and may have less enduring consequences. However, unlike the case in previous work (Baron et al., 1995; McCusker & Gettings, 1997; Molde et al., 2010; Vizcaino et al., 2013), there was some evidence of a (non-specific) gambling bias, analogous to biases for negative distractors, in our low-risk gambler group. One reason we detected such a bias, where others have not, may be that we included both non-problem and low-risk gamblers as our control group, whereas others have used non-gamblers, non-problem gamblers, or a mixture of both (Baron et al., 1995; Brevers, Cleeremans, Tibboel et al., 2011; McCusker & Gettings, 1997; Molde et al., 2010; Vizcaino et al., 2013).

As noted, low-risk gamblers displayed attentional biases for negative and gambling stimuli, whereas biases were specific to gambling items in high-risk

gamblers.[6] This absence of a bias for negative items in the high-risk group is interesting, as biases for negative items are reported in the general population and have been discussed in terms of evolutionary adaptability (Bradley, Codispoti, Cuthbert, & Lang, 2001). One possibility is that as an addictive behaviour becomes more problematic, stimuli that are not related to that behaviour lose salience. For instance, neurophysiological work shows that opiate users have stronger P300 responses to drug-related stimuli than to affective or neutral stimuli and lack the typical enhancement of event-related potentials for non-drug affective stimuli (Lubman et al., 2008). Neurobiological models of addiction also suggest that as individuals increase their involvement with addictive behaviours and substances, neural systems involved in processing natural rewards and threats become dysregulated (Koob et al., 2004).

Evidence for altered reward processing in the high-risk gambler group also comes from group differences in positive distractor effects. In both high- and low-risk groups, there was a facilitative effect of positive stimuli on disengagement, although this was more consistently observed across measures in low-risk gamblers. Accuracy was highest for targets that were preceded by positive distractors in low- and high-risk gamblers, at least at the 800-ms time lag. However, only the low-risk group demonstrated speeded disengagement from positive distractors according to the disengagement efficiency score results. Previous research has found that positive mood promotes certain cognitive functions (Dreisbach & Goschke, 2004; Rowe, Hirsh, & Anderson, 2007), and so perhaps processing of positive cues had similar effects on target responses for low-risk gamblers. It is unclear why the high-risk group did not show this same facilitated disengagement. As noted, one possibility is that positive affective stimuli lose their ability to alter attentional processes for individuals with addiction problems because of deviations in the brain's reward circuits (Koob et al., 2004).

The present study has several important implications for better understanding the nature and treatment of problem gambling. First, prolonged gambling-specific biases in the high-risk gamblers suggest the possibility that sustained attention to gambling cues might be involved in the etiology or maintenance of problem gambling. As attention is a limited resource (Kastner & Ungerleider, 2001), if high-risk gamblers maintain their attention to gambling cues in their environments, they may have few attentional resources free to apply adaptive cognitive or behavioural strategies when they are most needed (e.g., when encountering gambling-salient cues during a quit attempt). In contrast, if we had seen biases at the level of initial orienting responses, this would suggest that gamblers preferentially orient to gambling cues in their environments, but recover attentional resources quickly. Thus, sustained attentional biases would be more problematic in real-world settings. Prolonged gambling-specific biases might represent noteworthy targets for clinical intervention. Clinical studies could also investigate whether reducing sustained attention to gambling cues

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[6]These differences in pattern of attentional biases across gambler groups cannot be explained by differences in valence and arousal ratings for the different classes of distractors, as high- and low-risk gamblers' ratings of negative and gambling pictures were not significantly different.

in high-risk gamblers is accompanied by changes in gambling behaviour. Clinical studies with alcohol-dependent patients suggest that addiction-related attentional biases can be modified and that attentional bias modification affects alcohol treatment success (Schoenmakers et al., 2010). Future work is warranted to assess the malleability of gambling biases in high-risk gamblers.

Several potential limitations of the study should be considered. First, the high- and low-risk groups were aggregates of moderate-risk and problem gamblers and of low-risk and non-problem gamblers, respectively. Therefore, we cannot say whether the specificity of the bias for gambling stimuli, in the absence of a bias for negative stimuli, is particular to problem gamblers or is also seen in moderate-risk gamblers. A related study limitation is that we did not include a non-gambler control group. Future research should incorporate non-gamblers to determine whether the bias for both negative and gambling items is specific to low-risk gamblers or appears in the general population. We also need to consider whether the RSVP task is a pure measure of attentional bias, or whether confounding processes (i.e., learning) are at play. It is conceivable that gambling distractor effects in high-risk gamblers emerged because of gambling distractor effects on cross-trial learning rather than because of attention. However, if this were the case, we would expect to see poor split-half reliabilities for the gambling trials; instead, we observed that the split-half reliabilities were satisfactory to high for all trial types. In terms of the selected distractors, the negative stimuli were more arousing than the positive stimuli, which may have contributed to the low-risk gamblers' bias for negative distractors. This is a common problem that arises in research with emotional stimuli, as it is difficult to balance positive and negative stimuli on arousal ratings (Greenwald, Cook, & Lang, 1989). Another limitation was our failure to include a set of non-gambling addiction-relevant distractors (e.g., alcohol); therefore, we cannot conclude whether biases in the high-risk gambling group are specific to gambling cues or occur for addiction-relevant cues more generally. On a similar note, high-risk gambling and heavy alcohol use often co-occur (Grant, Kushner, & Kim, 2002), and so it would have been informative to have data on participants' drinking habits to determine whether history of alcohol use contributed to group differences in task performance. However, considering that group effects emerged only for specific trial types, and not at the level of overall task performance, it appears that there was no general impairment in performance in the high-risk gamblers.

In summary, high-risk gamblers showed sustained attentional biases to gambling-specific distractors. Low-risk gamblers showed some evidence of non-specific attentional biases (for negative and gambling pictures), as well as facilitated disengagement following positive pictures. These findings highlight differences in attentional processes between high- and low-risk gamblers and suggest that sustained attentional biases might be worthy targets for clinical interventions.

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Amanda Hudson, PhD, Department of Psychology and Neuroscience, Dalhousie University, Halifax, Canada. E-mail: a.hudson@dal.ca

Appendix A

Positive   Neutral

Negative   Gambling

Figure A1. Examples of pictures from publicly accessible sources, which resemble International Affective Pictures System (IAPS) pictures. Copyright restrictions prevented inclusion of images from the IAPS manual.

Appendix B

Figure B1. Series of trial events for last elements of a 200-ms lag trial, beginning with a gambling distractor, followed by a filler image, a rotated target, and response prompts.