



AKADÉMIAI KIADÓ

Affective impulsivity moderates the relationship between disordered gambling severity and attentional bias in electronic gaming machine (EGM) players







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FULL-LENGTH REPORT



ABSTRACT

Background and aims: Attentional bias to gambling-related stimuli is associated with increased severity of gambling disorder. However, the addiction-related moderators of attentional bias among those who gamble are largely unknown. Impulsivity is associated with attentional bias among those who abuse substances, and we hypothesized that impulsivity would moderate the relationship between disordered electronic gaming machine (EGM) gambling and attentional bias. *Methods:* We tested whether facets of impulsivity, as measured by the UPPS-P (positive urgency, negative urgency, sensation seeking, lack of perseverance, lack of premeditation) and the Barratt Impulsiveness Scale-11 (cognitive, motor, non-planning) moderated the relationship between increased severity of gambling disorder, as measured by the Problem Gambling Severity Index (PGSI), and attentional bias. Seventy-five EGM players participated in a free-viewing eye-tracking paradigm to measure attentional bias to EGM images. *Results:* Attentional bias was significantly correlated with Barratt Impulsiveness Scale-11 (BIS-11) motor, positive urgency, and negative urgency. Only positive and negative urgency moderated the relationship between PGSI scores and attentional bias. For participants with high PGSI scores, higher positive and negative urgency were associated with larger attentional biases to EGM stimuli. *Discussion:* The results indicate that affective impulsivity is an important contributor to the association between gambling disorder and attentional bias.

KEYWORDS

attentional bias, impulsivity, urgency, eye gaze tracking, gambling disorder, electronic gaming machines

INTRODUCTION

An attentional bias (AB) is defined as preferential attention to personally relevant stimuli (Crombez, Van Ryckeghem, Eccleston, & Van Damme, 2013). Applied to the present research, an individual who engages in gambling may exhibit heightened attention to gambling-related images compared to control images. Previous studies have shown that, like substance use disorders, disordered gambling can result in an AB for gambling-related stimuli (Hønsi, Mentzoni, Molde, & Pallesen, 2013). For example, a recent study reported that individuals who gamble on electronic gaming machine (EGMs) preferentially attend to EGM stimuli compared to non-EGM stimuli, unlike non-EGM players (Kim et al., 2021).

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The presence and strength of ABs in gambling may have important clinical implications because they have been shown to increase cravings and the risk of relapse for substance use disorders (Field, 2005; Field, Munafò, & Franken, 2009) and may also have similar effects among people with a gambling disorder.

According to the incentive-sensitization theory of addictions, repeated engagement in addictive behaviors can lead to a neuroadaptation of brain circuits (Robinson & Berridge, 2008). Through repeated engagement, addictive behaviors and their related cues take on an incentive salience, which increases the likelihood of engaging in the addiction. One consequence of incentive salience is the dysregulation of the dopamine reward system, which can become hypersensitive to addiction-related cues (Robinson & Berridge, 1993). In the context of EGM use, when an individual repeatedly gambles on EGMs, EGMs and their related cues take on an incentive-salience. The sensitization of gambling-related cues can lead to gambling behaviors through unconscious processes, including the development of ABs. This is because the gambling-related cues have taken on an incentive-salience and thus are more likely to result in attentional engagement (Berridge & Robinson, 2016), which leads to the activation of the dopamine reward system and results in heightened approach behaviors. The incentive-salience is more likely to occur when the addictive behavior is engaged in repeatedly and thus is more likely to develop among those experiencing disordered gambling (Berridge & Robinson, 2016; Kim et al., 2021). As such, the incentive-sensitization theory predicts that ABs for gambling-related cues will be heightened among individuals with disordered gambling.

Given the similarities between substance use disorders and disordered gambling, which can include subsyndromal as well as diagnosable gambling disorder (Balodis & Potenza, 2020; Petry et al., 2014), researchers have hypothesized that ABs may be involved in the development and maintenance of disordered gambling (Anselme & Robinson, 2020). Indeed, many studies have demonstrated that ABs develop in the context of gambling (Ciccarelli, Nigro, Griffiths, Cosenza, & D'Olimpio, 2016a, 2016b; Ciccarelli, Cosenza, Griffiths, Nigro, & D'Olimpio, 2019; Grant & Bowling, 2015; McGrath, Sears, Fernandez, & Dobson, 2020, see Hønsi et al., 2013, for a review). Moreover, McGrath, Meitner, and Sears (2018) found that AB tends to be the most pronounced for preferred gambling activities. For example, in their study, individuals who preferred to gamble on poker exhibited the largest ABs for poker-related stimuli compared to other types of gambling.

There is a growing literature on AB and gambling, and several studies have reported associations between AB and severity of gambling (Ciccarelli, Griffiths, Cosenza, Nigro, & D'Olimpio, 2020; Kim et al., 2021), as well as associations between AB and gambling-related measures such as the frequency of gambling, attitudes, beliefs, expectancies, and cravings (Grant & Bowling, 2015; Kim et al., 2021). In addition, associations between AB and depression, alcohol use, and stress have been reported (Ciccarelli et al., 2019;

McGrath et al., 2020; Kim et al., 2021). It should be noted that not all studies have observed these relationships. For example, Ciccarelli et al. (2016a) did not find an association between AB and depression or anxiety in their sample of non-problem and problem gamblers. In the present study, we contribute to the literature on the correlates of AB and gambling by examining impulsivity as a potential moderator of the disordered gambling-AB association.

Impulsivity and attentional bias in gambling

Impulsivity is a multi-faceted personality trait defined as a “predisposition toward rapid, unplanned reactions to internal or external stimuli without regard to the negative consequences of these reactions to the impulsive individual or to others” (Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001, p. 1784). It has been theorized that impulsivity is a core feature of disordered gambling, and it plays a prominent role in the influential pathways model of gambling (Blaszczynski & Nower, 2002). The role of impulsivity in gambling was highlighted in a recent meta-analysis of case-control studies that concluded that disordered gambling is associated with heightened levels of impulsivity in various domains (Ioannidis, Hook, Wickham, Grant, & Chamberlain, 2019).

Trait impulsivity is typically measured through self-report questionnaires, with two of the most widely used measures being the Barratt Impulsiveness Scale-11 (BIS-11; Patton, Stanford, & Barratt, 1995) and the UPPS-P (Lynam, Smith, Whiteside, & Cyders, 2006). Several studies have documented a relationship between scores on the BIS-11 and gambling (e.g., Marazziti et al., 2014), and in particular, a robust association between the motor aspect of the BIS-11 and disordered gambling (Lutri et al., 2018). A meta-analysis of motor-impulsivity and gambling found a large weighted mean effect size (0.96) for the BIS-motor subscale, suggesting motor impulsivity is important for understanding gambling disorder (Chowdhury, Livesey, Blaszczynski, & Harris, 2017). Similar to the BIS-11, there are several aspects of the UPPS-P that have been identified as particularly important in disordered gambling. Specifically, previous studies have reported a robust relationship between the affective components of the UPPS-P (positive and negative urgency) and gambling (Canale, Vieno, Bowden-Jones, & Billieux, 2017; Kim, Poole, Hodgins, McGrath, & Dobson, 2019; Navas et al., 2017; Rogier, Colombi, & Velotti, 2020).

Impulsivity has long been proposed to influence the strength of AB in substance use (Field & Cox, 2008), and this relation was supported in a meta-analytic review (Coskunpinar & Cyders, 2013). Coskunpinar and Cyders (2013) provided a theoretical account of the potential moderating role of impulsivity in addictive behaviors and AB. According to this account, impulsivity and AB share underlying neurological processes. Specifically, dopaminergic response to addiction-related cues such as gambling stimuli result in the activation of several regions of the brain, including the dorsolateral-frontal and ventromedial-frontal cortices. These cortical areas have also been associated with impulsivity

(e.g., Ziegler et al., 2019). If AB and impulsivity are neurologically associated, they may interact and increase the proclivity to engage in gambling. Dopaminergic systems that become hypersensitized to addiction-related cues have also been suggested to underlie impulsivity and impulsive choices (Mitchell & Potenza, 2014). Thus, it is possible that AB to gambling-related cues will be heightened among gamblers high in impulsivity because of the activation of similar brain regions.

Preliminary support for the influence of impulsivity on AB in gambling was reported by Ciccarelli et al. (2020), who found that behavioral impulsivity (risk-taking, as measured by the Balloon Analogue Risk Task) mediated the relationship between AB and gambling severity. To our knowledge, however, no study has examined the relationship between *trait* impulsivity and AB in disordered gambling, which is a question broader in scope. In the present study we tested whether trait impulsivity is a moderator of the relationship between disordered gambling (the predictor variable) and AB (the outcome variable). Based on previous research, we hypothesized that 1) motor impulsivity, negative urgency, and positive urgency would be associated with ABs to EGM stimuli when controlling for important covariates (age, gender, and PGSI scores), and 2) these facets of impulsivity would moderate the relationship between gambling severity and AB, such that the largest ABs would be observed for participants with high levels of impulsivity and high gambling severity scores.

METHODS

Participants

Eighty-five participants were recruited from a university campus and from the community. Undergraduate students were recruited via a research participation system and flyers posted on campus. Individuals from the community were recruited via advertisements on Facebook and Kijiji. The eligibility criteria were as follows: (1) age between 18 and 60, (2) regularly gambled on EGMs, defined as betting on EGMs once per month (at minimum) for the past three months, (3) had never sought treatment for a gambling disorder, either in the past or currently, (4) no intention to quit gambling in the next 30 days, and (5) no reported color blindness. The 85 individuals who participated in the laboratory visit were part of a larger study investigating gambling-related predictors of AB (see Kim et al., 2021).

Stimuli

The eye-tracking task consisted of two practice trials and 84 experimental trials, with each trial being presented for 6 s. Each trial displayed four images on a light grey background, with each image measuring 300 pixels in height and 400 pixels in width. All images were obtained from subscription stock photo websites. Images were either EGM-related ($n = 28$) or neutral ($n = 308$) and did not include faces, words, alcohol, or commercial logos. The EGM images depicted a

variety of slot machines and video lottery terminals. The neutral images featured stimuli that resembled EGMs in color and physical characteristics, such as data storage towers and arcade games. For the EGM trials, one EGM image and three neutral images were shown. For each EGM trial, we selected neutral images that best matched the EGM image in perceptual characteristics such as colour, brightness, contrast, and framing. For example, an EGM image that showed an EGM with a green colour scheme was matched to three neutral images with a green colour scheme and similar contrast and brightness. For some of the neutral images we used software to modify their contrast and colour to ensure that they matched the EGM image as closely as possible.

For the EGM trials, the EGM-related image was placed in each quadrant (upper left, upper right, lower left, and lower right) an equal number of times. The remaining 56 trials consisted of four neutral images. These filler trials were used to reduce the relative frequency of the EGM-related images during the task (i.e., the majority of the images were neutral images), thereby reducing their conspicuousness and decreasing the potential influence of demand characteristics (e.g., participants hypothesizing that they should focus on EGM images). The eye-tracking data from the filler trials were not analyzed. The trials were presented in a random order during the eye-tracking task.

Measures

Disordered gambling. The Problem Gambling Severity Index (PGSI; Ferris & Wynne, 2001) was used to assess the severity of disordered gambling. The PGSI is a nine-item self-report questionnaire that asks respondents about potential problems that result from their gambling, including financial difficulties and health issues. Responses are coded on a scale from 0 (“never”) to 4 (“almost always”) and the scores for the nine items are summed for a total score. For our sample, the coefficient alpha for the PGSI was 0.85.

BIS-11. The BIS-11 (Patton et al., 1995) assesses impulsivity with three subscales: (1) cognitive, which involves making quick decisions, (2) motor, which consists of difficulty withholding action, and (3) non-planning, or acting without thought (Stanford et al., 2009). The BIS-11 is a self-report measure that consists of 30 statements, with responses anchored from 1 (“rarely/never”) to 4 (“almost always/always”). Scores are calculated from the sum of the subscale items, with higher scores reflecting greater impulsivity within the factor being assessed. Coefficient alpha for the BIS-11 was 0.65 in our sample, and for the subscales (attentional, motor, and non-planning) the alphas were 0.56, 0.71, and 0.71, respectively.

UPPS-P. The UPPS-P Impulsive Behavior Scale (Lynam et al., 2006) is a 59-item self-report measure that assesses five facets of impulsivity: (1) sensation seeking, defined as the tendency to seek out new and exciting experiences, (2) lack of premeditation, or difficulties thinking through potential



consequences, (3) lack of perseverance, defined as difficulties in remaining focused, (4) negative urgency, or the tendency to be impulsive during negative affective experiences, and (5) positive urgency, defined as the tendency to be impulsive during positive experiences. Responses are anchored from 1 (“agree strongly”) to 4 (“disagree strongly”). Each item corresponds to one of the facets of impulsivity and item responses are averaged to form a composite score for the five subscales. Higher scores reflect greater impulsivity for each facet measured. Coefficient alpha in our sample for the 59-item scale was 0.85, with similarly high reliabilities for the sensation seeking ($\alpha = 0.85$), lack of premeditation ($\alpha = 0.86$), lack of perseverance ($\alpha = 0.83$), negative urgency ($\alpha = 0.88$), and positive urgency ($\alpha = 0.95$) subscales.

Attentional bias. A unitary measure of AB was calculated for each participant by subtracting the average total fixation time in milliseconds for the neutral images from the average total fixation time for the EGM images (i.e., average total fixation time for EGM images – average total fixation time for neutral images). AB values significantly greater than 0 milliseconds (ms) indicated that a participant spent more time, on average, attending to the EGM images compared to the neutral images. Conversely, AB values significantly less than 0 ms indicated that the participant spent more time, on average, attending to the neutral images compared to the EGM images. We chose total dwell time as our measure of attention because we wanted to assess individual differences in attentional engagement with the images rather than the initial orientation or capture of attention. Moreover, in free-viewing paradigms, as used in the present study, total dwell times have superior psychometric properties (internal consistency and test-retest reliability) relative to first fixation indices (e.g., Waechter, Nelson, Wright, Hyatt, & Oakman, 2014; Lazarov, Abend, & Bar-Haim, 2016; Skinner et al., 2018).

Eye-tracking apparatus

The EyeLink 1000 eye-tracking system (SR Research Ltd, Ottawa, Ontario, Canada) recorded eye movements using infrared video technology. The system captures 1000 samples per second, requires approximately 1 ms for eye-tracking information to be transmitted, and the average reported gaze location is accurate to within less than 0.5° . Participants viewed the images on a 24-inch LCD monitor using a chin and headrest placed approximately 60 cm from the monitor. The chin and headrest were used to help minimize head movements, thereby increasing tracking accuracy.

Procedure

Participants provided written informed consent upon arrival at the lab. Participants were informed that they would complete an eye-tracking task followed by a series of questionnaires. The eye-tracking data was collected in a dedicated room. The 84 sets of images presented were the same for each participant, but the order of trials was randomized

separately for each participant. Participants were instructed to view the images “in any way you like, almost as if you were watching television”. Calibration and validation procedures were completed before the two practice trials. There was a gaze position check between each trial to ensure accurate eye-gaze measurement was maintained throughout the 84 trials. The eye-tracking task required approximately 10 min, after which participants returned to the main lab area to complete the self-report questionnaires. At the end of the visit each participant was fully debriefed and compensated with a CAD \$40 gift card.

Processing of eye-tracking data

Eye-tracking data were processed using the EyeLink Data Viewer analysis software (SR Research). The default settings of this software filters for blinks, missing data, and other recording artifacts.

Statistical analysis

All statistical analyses were carried out using the Statistical Package for the Social Sciences (SPSS, version 26, IBM Corp, 2019). Two participants, one community and one student, did not indicate their age; their ages were imputed using the mean age from the community and student samples, respectively. Regression analyses were used to identify multivariate outliers. Two participants were identified as outliers, defined as having a Studentized residual greater than 3.0, and these two participants were excluded from all analyses. Eight participants had poor quality eye-tracking data due to calibration issues or inadequate tracking and their data were excluded from all analyses, resulting in a final sample size of 75 participants.

Pearson correlations were used to examine bivariate relationships between trait impulsivity and AB. Hierarchical multiple regression models were used to determine whether facets of impulsivity that correlated with AB remained statistically significant ($P < 0.05$) when controlling for PGSI scores, age, and gender. As PGSI scores are known to be positively correlated with both impulsivity and AB (e.g., Ioannidis et al., 2019; Kim et al., 2021), controlling for PGSI scores in these analyses ensured that any associations between measures of impulsivity and AB were not due to higher PGSI scores. Similarly, age and gender are associated with impulsivity, such that men and those of younger age have higher levels of impulsivity (Chamorro et al., 2012; Cross, Copping, & Campbell, 2011), and thus controlling for these variables in the regression analyses was important. Multiple regression was also used to determine if facets of impulsivity that were significant in the correlation analyses moderated the relationship between gambling disorder severity and AB; for example, if larger ABs would be observed for participants with high levels of impulsivity and gambling disorder severity.

An a priori power analysis indicated that a minimum sample size of 75 participants was required to provide adequate power to detect significant ($P < 0.05$) increases in variance accounted for by the interaction (moderation) effect

(i.e., increase in R^2). More specifically, the power estimates using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) to detect small-to-medium-sized effects ($f^2 = 0.10$ to 0.15 ; Cohen, 1988) ranged from 77.0% to 91.1% using an alpha error probability of 5%. Statistically significant moderation effects were probed using PROCESS (version 3.4.1; Hayes, 2018; Hayes & Rockwood, 2017), a regression-based analytical tool that provides follow-up tests of interactions. We recruited more than 75 participants to account for attrition and equipment/calibration difficulties with eye-tracking that can result in the loss of data or poor-quality data.

Ethics

This study was approved by the research ethics board at the University of Calgary. All participants provided informed consent prior to beginning the study. The data from this study are available upon request (contingent on approval from the research ethics board).

RESULTS

Sample characteristics

Table 1 shows the demographic characteristics of the sample. Fifty-three participants (70.7%) were recruited from the

community and 22 from the university (29.3%). The mean age of the sample was 34.11 ($SD = 13.57$). There were similar numbers of women ($n = 37$; 49.3%) and men ($n = 38$; 50.7%). Twenty-one participants (28.0%) reported being in a relationship. Most of the participants were White ($n = 54$; 72.7%) and had a high school or post-secondary education ($n = 76$; 98.7%). The mean score on the PGSI was 4.03 ($SD = 4.47$), with 25 participants (33.3%) classified as meeting the threshold for disordered gambling as indicated by a score of 5 or greater (Currie, Hodgins, & Casey, 2013). There were several differences between participants recruited from the community and those recruited from the university. Specifically, there were more males in the community sample, and they were older, more likely to be married, and had higher PGSI scores than participants recruited from the university.

Correlation analyses

Table 2 shows the correlations between AB and the self-report measures. As predicted, there were statistically significant ($P < 0.05$) positive correlations between AB and BIS-motor, negative urgency, and positive urgency scores. In contrast, none of the correlations between AB and BIS-attention, BIS-non-planning, lack of premeditation, lack of perseverance, or sensation seeking were statistically significant.

Table 1. Demographic characteristics and comparisons between participants recruited from the community and the university

Characteristic	Total $N = 75$	Community $n = 52$	University $n = 25$	χ^2	t	P
Age in years, mean (SD)	34.11 (13.57)	39.04 (12.99)	22.24 (4.72)		8.12	<0.001
Gender, n (%)				6.82		0.009
Male	38 (50.7)	32 (60.4)	6 (27.3)			
Female	37 (49.3)	21 (39.6)	16 (72.7)			
Ethnicity, n (%)				1.67		0.431
White	54 (73.0)	39 (75.0)	15 (68.2)			
Non-white	20 (27.0)	13 (25.0)	7 (31.8)			
Marital status, n (%)				4.25		0.001
Married/common-law	21 (28.0)	21 (39.6)	0 (0.0)			
Not married/common-law	54 (87.2)	32 (60.4)	22 (100.0)			
PGSI	4.03 (4.47)	5.11 (4.74)	1.41 (2.18)		4.64	<0.001

Note. PGSI = Problem Gambling Severity Index.

Table 2. Intercorrelations between attentional bias, UPPS-P (negative urgency, premeditation, perseverance, sensation seeking, and positive urgency), BIS-11 (cognitive, motor, non-planning), and PGSI

Variable	1	2	3	4	5	6	7	8	9	10
1. Attentional Bias	-	0.31**	0.04	0.08	-0.07	0.40**	0.04	0.25*	0.22	0.44**
2. Negative Urgency		-	0.35**	0.57**	0.04	0.73**	0.39**	0.38**	0.24**	0.06
3. Premeditation			-	0.60**	0.16	0.33**	0.48**	0.39**	0.39**	-0.12
4. Perseverance				-	-0.12	0.37**	0.47**	0.19	0.38**	-0.12
5. Sensation Seeking					-	0.14	0.11	0.20	-0.14	-0.26**
6. Positive Urgency						-	0.18	0.34**	0.17	0.14
7. BIS-Cognitive							-	0.51**	0.32**	-0.12
8. BIS- Motor								-	0.45**	0.22
9. BIS- Non-planning									-	0.36**
10. PGSI										-

Note. ** $P < 0.01$, * $P < 0.05$. BIS = Barratt Impulsiveness Scale-11. PGSI = Problem Gambling Severity Index.



Regression results

Hierarchical multiple regression was used to examine associations between AB and the correlated measures of impulsivity (BIS-motor, negative urgency, positive urgency), controlling for age, gender, and PGSI scores initially, and then testing for an interaction between each impulsivity measure and PGSI scores. That is, to determine if a particular facet of impulsivity (as measured by BIS-motor, negative urgency, and positive urgency scores) moderated the relationship between gambling severity (the predictor variable) and AB (the outcome variable), an interaction term (impulsivity measure x PGSI score) was added to each model and the increase in R^2 was tested for significance.

Analysis of BIS-motor scores. As can be seen in Table 3, Model 1, with three predictors (age, gender, and PGSI scores), was statistically significant, $R = 0.49$, $R^2 = 0.24$, $F(3, 71) = 7.29$, $P < 0.001$, accounting for a significant percentage of the variation in AB. As predicted, PGSI scores were a significant predictor of AB while controlling for age and gender, $t(71) = 4.31$, $P < 0.001$. Adding the BIS-Motor scores to the model (Model 2) did not increase R^2 significantly, $F(1, 70) = 1.76$, $P = 0.189$. Thus, BIS-Motor scores did not account for variation in ABs beyond that accounted for by age, gender, and PGSI scores. This was also the case when the BIS-motor x PGSI interaction term was added to the model (Model 3), $F(1, 69) = 0.79$, $P = 0.378$. This analysis showed that this facet of impulsivity, as measured by the BIS-motor subscale, was not an independent predictor of AB, nor was the association between PGSI scores and AB moderated by BIS-motor scores.

Analysis of negative urgency scores. Table 4 shows the results of the regression analysis using negative urgency

Table 3. Hierarchical multiple regressions with attentional bias as the dependent variable. PGSI score, age, and gender entered in Model 1. BIS-motor entered in Model 2. PGSI x BIS-motor interaction term entered in Model 3

BIS-Motor	R^2	ΔR^2	ΔF	β	t	P
Model 1	0.236	0.236	7.29			<0.001
PGSI				0.50	4.31	<0.001
Age				-0.17	-1.50	0.138
Gender				0.14	1.35	0.183
Model 2	0.254	0.019	1.76			0.189
PGSI				0.47	3.91	<0.001
Age				-0.16	-1.39	0.168
Gender				0.13	1.29	0.200
BIS-motor				0.14	1.33	0.189
Model 3	0.263	0.008	0.79			0.378
PGSI				-0.39	-0.40	0.690
Age				-0.14	-1.21	0.231
Gender				0.16	1.50	0.138
BIS-motor				0.01	0.04	0.965
PGSI x BIS-motor				0.89	0.89	0.378

Note. PGSI = Problem gambling severity index. BIS = Barratt Impulsiveness Scale-11. The value of R^2 is cumulative.

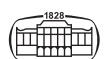
Table 4. Hierarchical multiple regressions with attentional bias as the dependent variable. PGSI score, age, and gender entered in Model 1. Negative urgency entered in Model 2. PGSI x negative urgency interaction term entered in Model 3

Negative Urgency	R^2	ΔR^2	ΔF	β	t	P
Model 1	0.236	0.236	7.29			<0.001
PGSI				0.50	4.31	<0.001
Age				-0.17	-1.50	0.138
Gender				0.14	1.35	0.183
Model 2	0.304	0.068	6.89			0.011
PGSI				0.47	4.17	<0.001
Age				-0.14	-1.20	0.233
Gender				0.13	1.27	0.209
Negative Urgency				0.27	2.62	0.011
Model 3	0.374	0.070	7.68			0.007
PGSI				-0.83	-1.72	0.090
Age				-0.18	-1.70	0.100
Gender				0.14	1.45	0.152
Negative Urgency				-0.02	-0.17	0.867
PGSI x Negative Urgency				1.39	2.77	0.007

Note. PGSI = Problem gambling severity index. The value of R^2 is cumulative.

scores. (Note that the statistics for Model 1 are identical to the previous analysis of BIS-motor scores because the same three predictors are used to predict AB: age, gender, and PGSI scores). The addition of negative urgency scores to the model (Model 2) produced a statistically significant increase in R^2 , $F(1,70) = 6.89$, $P = 0.011$, increasing the percentage of variance accounted for by 6.8%. Thus, negative urgency accounted for variation in AB beyond that accounted for by age, gender, and PGSI scores. Adding the negative urgency x PGSI interaction term to the model (Model 3) further increased R^2 by 7.0%, $F(1,69) = 7.68$, $P = 0.007$, reflecting a significant moderation effect. This relationship is shown in Fig. 1. As predicted, participants with high PGSI scores and high negative urgency scores had the largest ABs. Follow-up tests showed that when negative urgency scores were low ($M = 1.85$), corresponding to one standard deviation below the mean negative urgency score, higher PGSI scores were not associated with larger AB, $t(69) = 1.54$, $P = 0.127$ (i.e., the slope of the line was not significantly different than zero). In contrast, when negative urgency scores were average ($M = 2.28$), higher PGSI scores were associated with larger AB, $t(69) = 5.02$, $P < 0.001$. This was also true when negative urgency scores were high ($M = 3.11$), corresponding to one standard deviation above the mean, $t(69) = 4.70$, $P < 0.001$. These results show that negative urgency significantly moderated the relationship between problem gambling symptoms and AB for EGM images: this association was stronger for participants with higher negative urgency scores.

Analysis of positive urgency scores. Table 5 shows the results of the regression analysis using positive urgency scores.



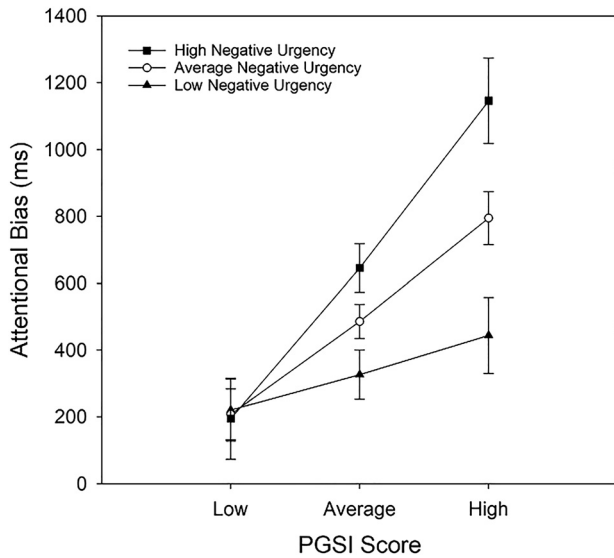


Fig. 1. Attentional bias as a function of PGSI scores and negative urgency scores. Error bars show one standard error of the mean

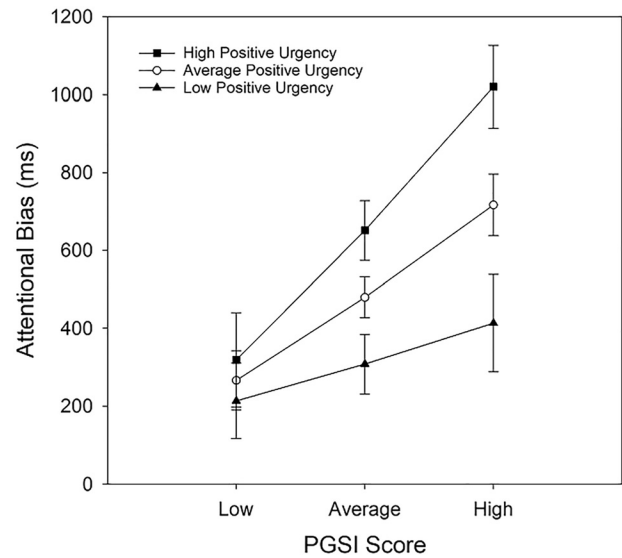


Fig. 2. Attentional bias as a function of PGSI scores and positive urgency scores. Error bars show one standard error of the mean

Table 5. Hierarchical multiple regressions with attentional bias as the dependent variable. PGSI score, age, and gender entered in Model 1, Positive urgency entered in Model 2. PGSI x Positive urgency interaction term entered in Model 3

Positive Urgency	R ²	ΔR ²	ΔF	β	t	P
Model 1	0.236	0.236	7.29			<0.001
PGSI				0.50	4.31	<0.001
Age				-0.17	-1.50	0.138
Gender				0.14	1.35	0.183
Model 2	0.322	0.086	8.90			0.004
PGSI				0.43	3.75	<0.001
Age				-0.08	-0.73	0.470
Gender				0.07	0.68	0.501
Positive Urgency				0.32	2.98	0.004
Model 3	0.362	0.040	4.31			0.042
PGSI				-0.23	-0.69	0.494
Age				-0.08	-0.67	0.507
Gender				0.07	0.72	0.475
Positive Urgency				0.10	0.66	0.510
PGSI x Positive Urgency				0.74	2.08	0.042

Note. PGSI = Problem gambling severity index. The value of R² is cumulative.

The addition of positive urgency scores to the model (Model 2) produced a statistically significant increase in R² (8.6%), $F(1,70) = 8.90, P = 0.004$. Thus, like negative urgency, positive urgency was a significant predictor of AB when controlling for age, gender, and PGSI scores. Adding the positive urgency x PGSI interaction term to the model (Model 3) further increased R² by 4.0%, $F(1, 69) = 4.31, P = 0.042$, reflecting a significant moderation effect. Figure 2 shows the relationship between PGSI scores, AB, and positive urgency scores. Once again, as predicted, participants with high PGSI scores and high positive urgency scores had the largest AB. Follow-up tests showed when positive

urgency scores were low ($M = 1.25$), higher PGSI scores were not associated with larger AB, $t(69) = 1.23, P = 0.219$, whereas when positive urgency scores were average ($M = 1.97$) and high ($M = 2.69$), higher PGSI scores were associated with larger AB, $t(69) = 3.94, P < 0.001$, and $t(69) = 4.10, P < 0.001$, respectively. Together these results show that positive urgency, like negative urgency, significantly moderated the relationship between problem gambling symptoms and AB for EGM images.

DISCUSSION

The results of our study both converged with and diverged from our hypotheses. Consistent with our hypotheses, BIS-motor, negative urgency, and positive urgency scores were significantly correlated with AB. Contrary to our hypotheses, only positive and negative urgency, and not BIS-motor, were significant predictors of AB when controlling for PGSI scores, age, and gender. We also found that both aspects of affective impulsivity moderated the relationship between gambling severity and AB, such that ABs were most pronounced for participants with higher levels of positive and negative urgency and gambling severity. That is, participants with higher levels of problem gambling symptoms were prone to larger ABs when their affective impulsivity scores were also high.

The results of our study suggest that positive and negative urgency may interact with AB to maintain and exacerbate disordered gambling, possibly due to a synergistic effect (Coskunpinar & Cyders, 2013). Individuals with disordered gambling have a heightened incentive-salience to gambling-related cues given their repeated engagement with gambling and the hypersensitization of the dopamine reward system. As a consequence, individuals with disordered gambling are more likely to attend to gambling-related cues in their



environment and have greater difficulties disengaging from them. In turn, gambling-related cues can result in cravings and urges, which are experienced as distressing emotions (Raylu & Oei, 2004; Tavares, Zilberman, Hodgins, & el-Guebaly, 2005) and are a proximal risk factor for gambling (Ashrafioun & Rosenberg, 2012). Unfortunately, individuals high in affective impulsivity may be at a greater risk of gambling when triggered by cues in their environment, given their diminished ability to inhibit their impulses, which in turn serves to heighten the incentive salience of gambling-related cues and leaves them more vulnerable to future gambling episodes.

From a clinical perspective, it may be especially important for individuals with disordered gambling and high trait levels of affective impulsivity to learn strategies to tolerate negative emotional experiences (e.g., cravings) that lead to increased ability to inhibit impulses to gamble. To this end, distress tolerance and mindfulness-based interventions may be of particular benefit. These interventions can help individuals increase their tolerance of and ability to manage intense negative emotions, which in turn may inhibit prepotent responses such as gambling (Kim & Hodgins, 2018). Distress tolerance and mindfulness interventions involve a variety of cognitive, behavioural, and emotional strategies that help individuals become aware of their emotional experiences and how to tolerate and cope with them. For example, in distress tolerance interventions, individuals can be taught skills to engage in alternate behaviors to gambling when experiencing distressing emotions. Over time, the ability to inhibit gambling may in turn reduce the incentive-salience to gambling-related stimuli, leading to reduced cravings as they will become less likely to be triggered by cues in their environment.

We found that positive and negative urgency moderated the relationship between gambling severity and AB, whereas motor-impulsivity did not. This outcome is likely related to the free-viewing paradigm used in this study. Motor-impulsivity can be conceptualized as impulsivity in action; for example, difficulties in withholding the next spin on an EGM. The free-viewing paradigm does not require a motor response, so it is unlikely to have tapped into this facet of impulsivity strongly enough so that it would be associated with the AB measured in this paradigm. Motor-impulsivity may influence AB if participants are engaged in a task that requires a response, such as the modified Posner task. Moreover, a behavioral measure of impulsivity may have increased the validity of the measurement of motor impulsivity compared to the self-report BIS measure (Hodgins & Holub, 2015). Future research that examines these possibilities would be highly informative.

Limitations and directions for future research

Our findings should be interpreted considering the limitations of the study. First, only *trait* impulsivity was assessed as a potential moderator of AB. This is a limitation because previous studies in the substance use literature have reported that the relationship between AB and impulsivity is

influenced by both behavioral and trait impulsivity (e.g., Coskunpinar & Cyders, 2013). Second, the sample included only EGM players, and therefore our results may not generalize to those whose preferred form of gambling is different (e.g., poker or sports betting). Third, we did not assess whether participants were familiar with the EGMs depicted in the images, which could have influenced their attention to the images. Lastly, the cross-sectional design precludes conclusions regarding the causal nature of the observed relationships between gambling severity, positive and negative urgency, and AB in disordered gambling.

CONCLUSION

Our study contributes to the growing understanding of the development of AB in disordered gambling. We extend previous literature by providing evidence for the role that affective impulsivity plays in the relationship between gambling severity and AB. Given that both AB and affective impulsivity have been implicated in disordered gambling, the results further our understanding of the etiology of this addictive behavior and suggest approaches for possible treatments.

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