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ORIGINAL PAPER

Exploring the Relationship Between Stimulant Use and Gambling in College Students

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Abstract Both gambling and stimulant use are common and can lead to problems on college campuses with consequences that impact the financial, emotional, academic and physical well-being of students. Yet few studies have been conducted to understand the co-occurrence of these conditions and the increased risk factors if any that may exist for gambling and related problems. The present study is among the first to document the co-occurrence of these behaviors in both a random sample of students ($N = 4640$), and then to explore to what extent stimulant use impacts subsequent gambling and related problems 12 months later in an at-risk sample ($N = 199$). Results revealed a three-fold higher rate of recent problem gambling for those who used stimulants versus those who had not (11 vs. 4 %). For those already gambling, stimulant use predicted an increased frequency in gambling 12 months later. Implications for prevention and screening are discussed.

Keywords College students · Gambling · Stimulants · Comorbidity

Introduction

College students engage in myriad behaviors that may pose health risks, including gambling and drug use. Approximately 75 % of college students have gambled in the past year (Barnes et al. 2010), and although most engage in gambling in moderation, some exhibit behaviors indicative of disordered gambling (e.g., Blinn-Pike et al. 2007). One large meta-analysis suggests combined rates of subthreshold and probable pathological gambling disorder among college students are nearly triple that of the general adult population

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(Shaffer and Hall 2001 [6.07 % adult vs. 16.44 % college students]). A recent meta-analysis (Nowak and Aloe 2014) suggests the disparity may be greater; specifically, compared with 1.92 % of adults (Shaffer and Hall 2001), 10.23 % of college students may meet criteria for pathological gambling disorder (based on a South Oaks Gambling Screen [SOGS; Lesieur and Blume 1987] score of 5 or greater).

Independent of diagnostic status, gambling can be associated with a host of negative consequences, including increased rates of suicide and attempted suicide, work and educational disruption, as well as financial, relationship, and legal difficulties (e.g., Engwall et al. 2004; Gupta and Derevensky 2000; Neighbors et al. 2002; Rosenthal and Lorenz 1992; Stuhldreher et al. 2007). Additionally, gambling problems are frequently comorbid with alcohol use, drug use and other mental health conditions. A meta-analysis by Lorains et al. (2011) indicated among those who exhibit subthreshold or probable pathological gambling disorder, 57.5 % reported any substance use disorder, 37.9 % reported any mood disorder, and 37.4 % reported any anxiety disorder in their lifetime. Specifically among college students, disordered or more frequent gambling is positively associated with higher levels and problematic patterns of alcohol and other drug use (Bhullar et al. 2012; Engwall et al. 2004; Martens et al. 2009; Martin et al. 2014), including stimulants such as amphetamines (LaBrie et al. 2003; Lee et al. 2014).

Amphetamine Use on College Campuses

Among students in college, amphetamine use rose sharply from 5.7 % in 2008 to 10.1 % in 2014 (Johnston et al. 2015). Common types of amphetamine used on college campuses are stimulant medications (i.e. Ritalin, Concerta) which are often prescribed for students with ADHD/ADD. Prevalence of prescription stimulants misuse (use without prescriptions) among college students nationally represents a growing public health concern (Johnston et al. 2007; McCabe et al. 2007). Specifically, 5.9 % of young adults aged 18–25 reported current (past 30 days) non-medical use of prescription stimulants (NMUPS). Lifetime and past year prevalence was 20 and 13 % respectively (McCabe et al. 2009). Given the academic and other pressures faced by college students, prescription stimulants or other amphetamines are likely to be misused by students to stay awake and alert in order to complete their work and study for exams.

Many adverse effects among college students have been reported as a consequence of NMUPS: headaches (33 % of users), stomachaches (33 %), irritability (62 %), sad mood (25 %), and sleeping difficulties (72 %) (Rabiner et al. 2009, a). Compared to students who do not, those who misused or engaged in NMUPS reported more social difficulties and had lower grade point average (GPA) and reported concerns about their academic performance (Rabiner et al. 2009, a; Teter et al. 2003; McCabe et al. 2006). Additionally, college students abusing stimulant medication were more likely than students abusing other drugs to report drug related problems and to experience nine out of ten drug related problems as assessed by the drug abuse screening test-10 (DAST-10) (Skinner 1982).

Comorbidity of Stimulants and Other Substances

Adolescents and young adults have particularly high rates of concurrent polydrug use with up to 90 % of past-year nonmedical users of stimulants reporting using other drugs (McCabe et al. 2006; McCabe and Teter 2007; SAMHSA 2003, 2004). There is evidence that students who misused stimulant medications were more likely than those students who did not misuse them to have consumed alcohol and other drugs (Rabiner et al. 2009, a;

Teter et al. 2003; McCabe and Teter 2007; McCabe et al. 2005). Compared to non-users, NMUPS users are more likely to meet diagnostic criteria for dependence on alcohol and marijuana, skip classes more frequently, and spend less time studying (Arria et al. 2008; McCabe et al. 2005; SAMSHA 2004). These students are also likely to have used other drugs and experienced blackouts, engaged in illegal activities to obtain prescription drugs, and experienced withdrawal symptoms when they stopped taking them (McCabe and Teter 2007).

Stimulants and Gambling

There is a lack of research in regards to amphetamine and gambling in college students. Gambling has been reclassified within the substance-related and additive disorder category due to the research suggesting that impulsivity and disregard of long term consequences are essential features of both gambling and addictive behaviors as well as evidence that there is overlapping impulsivity features in gambling and addictive behaviors (Albein-Urios et al. 2014). Studies available with cocaine use (which has similar mechanisms and effects as amphetamine) that are available however point to the importance of further study in this topic (Hall et al. 2000). For example, Albein-Urios et al. (2012) examine pathological gamblers compared to cocaine addicts who are posited as similar in subjective experiences, reinforcing mechanisms, and patterns of use (binge using and abstaining) to pathological gamblers. Both groups had elevated positive urgency which is a dimension of impulsivity related to long term gambling problems, and poorer inhibition compared to control (Albein-Urios et al. 2012). Thus, cocaine use and gambling may be important to understand when used as the co-occurrence and co-morbidity may exacerbate problems.

Gambling can also mirror psychostimulant drug effects, such as behavioral perseveration and brain dopamine pathways, which suggests that psychostimulant drugs may induce effects similar to those of gambling (Zack and Poulos 2003, 2009). "DA [dopamine activation] critically mediates the arousal induced by psychostimulant drugs. The model outlined here implies that DA may play a similar role in the state of arousal that occurs in gambling" (Zack and Poulos 2009, p. 15) and gambling with high stakes may approximate this effect because uncertainty will further activate DA. There is also emerging evidence that amphetamines prime motivation to gamble. Zack and Poulos (2003) used a prototypic psychostimulant as a pharmacological prime, in problem gamblers and non-gambler controls. They found that AMPH primed self-reported gambling motivation. Furthermore, in gamblers, AMPH selectively increased reading speed to gambling words while slowing reading speed to neutral words, whereas similar results were not obtained in problem drinkers (Zack and Poulos 2003).

Study Aims

To date, there has been little to no research with gambling and amphetamine/prescription stimulant use among college students. Given the evidence to date, and to deepen the understanding and research available, this study explores the relationship between demographic variables, gambling and amphetamine use in a general random sample of college students. Furthermore, we explore how amphetamine use at baseline impacts gambling quantity, frequency, and problems in the future.

Methods

Participants and Recruitment

Participants were college students recruited from a large West Coast university. A list of 10,062 of randomly selected students from the registrar's database were invited to complete an online screening survey of alcohol, substance use, and gambling behaviors. Of these, 4640 (46 %) completed the survey and are included in cross-sectional analyses for the current study. This response rate is typical to studies using similar procedures (i.e. internet recruitment from registrar sample) (Larimer et al. 2007; McCabe et al. 2005; Thombs et al. 2005; Turrisi et al. 2009). Those who scored 3 or more on the South Oaks Gambling Screen (SOGS; Lesieur and Blume 1987) for lifetime gambling disorder, reported 1 or more consequences on the Gambling Problem Index (GPI; Neighbors et al. 2002), and met abuse or dependence criteria for alcohol or substance use (N = 233; 5.02 %) were further invited to complete a baseline assessment for a longitudinal gambling prevention trial (with web-based or in-person conditions and control), of which 199 completed the survey and enrolled in longitudinal trial (85.4 % of those eligible).

The screening sample ($N = 4640$) was 59.2 % female, averaged 19.8 years of age ($SD = 1.5$ years), and reported race/ethnicity was 57.4 % White, 28.5 % Asian, 1.2 % Black, and 12.9 % Multiracial or Other. Of the sample, 20.5 % were freshman, 23.1 % sophomores, 33.2 % juniors, 23.0 % seniors, and .3 % were graduates or not actively enrolled. The longitudinal sample of participants ($N = 199$) was 62.8 % male (this is due to males having higher incidents of problem gambling and substance use), averaged 20.1 years of age ($SD = 1.4$ years), reported race/ethnicity was 53.3 % White, 28.5 % Asian, and 1.2 % Black, 18.3 % Multiracial or Other, and 18.1 % were freshman, 22.1 % sophomores, 34.2 % juniors, and 25.6 % were seniors. The recruited sample (both screening participants and longitudinal participants) were similar to campus rate in terms of ethnicity (44 % White with additional 14 % International, 27 % Asian, 3.5 % Black and 11.5 % other), gender (52 % women), and age (mean age 20.8).

Measures and Assessment Procedures

All measures were completed online via a secure server using DatStat Illume. After viewing an informed consent statement containing all elements of informed consent, participants who agreed to continue were routed to the surveys. All data were identified only by a unique participant identification number. The screening survey took approximately 20 min to complete and participants were paid $10 for completion. Baseline and follow-up measures for eligible participants took approximately 30–45 min and participants were compensated $40 for baseline and $50 for 12 month follow-up. Screening, baseline, and 12-month data were used for the current analysis. All measures and procedures were reviewed and approved by the affiliated Institutional Review Board.

Demographics and Study Assignment

Screening demographic variables included gender (coded as female vs. male), race/ethnicity (White, Asian, Other), whether the participant was assigned to an intervention (web or in-person feedback) or to the control condition.

Gambling Frequency

Gambling frequency in the past 6 months was assessed using 12 items from the SOGS (Lesieur and Blume 1987). Participants indicated the frequency with which they engaged in 12 different types of gambling on a 5-point scale with 0 = *Never*, 1 = 1–10 *times*, 2 = *More than* 10 *times, but less than weekly*, 3 = *Weekly or more than once a week*, and 4 = *Daily*. An overall index of gambling frequency was calculated by summing across the 12 gambling frequency items. Cronbach's alpha for the gambling frequency items of the SOGS in the screening sample was .83.

Gambling Quantity

Gambling Quantity was measured with one item from the Gambling Quantity and Perceived Norms Scale (GQPN; Neighbors et al. 2002) that asked how much money participants spent (lost) gambling over the previous 6 months. The possible responses were on a 10-point scale with 0 = \$0, 1 = \$1–\$10, 2 = \$10–\$20, 3 = \$20–\$40, and 4 = \$40–\$60, 5 = \$60–\$100, 6 = \$100–\$200, 7 = \$200–\$500, 8 = \$500–\$1000, and 9 = *More than* \$1000.

Gambling Problems

South Oaks Gambling Screen (SOGS; Lesieur and Blume 1987) is a 20-item self-administered questionnaire designed to identify pathological gambling. A score of 5+ on the SOGS has been used to identify probable pathological gamblers, with scores of 3–4 representing at-risk gamblers (Dubé et al. 1996). Lifetime SOGS assessed at screening was used as part of the eligibility criteria for the longitudinal sample; past 6-months SOGS was assessed at each study time point as an index of current problem gambling. The Cronbach's alpha for the SOGS in the screening sample was .82. *Gambling consequences* in the past 6 months were assessed with the 20-item Gambling Problems Index (GPI, Neighbors et al. 2002). Higher scores on this measure indicate greater frequency of gambling-related problems. Cronbach's alpha for the GPI in the screening sample was .94.

Stimulant and Marijuana Use

The frequency of amphetamine-type stimulant and marijuana use in the past 3 months were each assessed with one item from the World Health Organization's (WHO) *alcohol, smoking, and substance involvement screening test* (ASSIST; WHO, 2002). The WHO ASSIST is a brief screening instrument to assess hazardous, harmful and dependent use of alcohol and other substances. To assess amphetamine use, participants were asked if they had used Amphetamine-type stimulants (speed, diet pills, ecstasy, etc.) in the past 3 months. To assess marijuana use, participants were asked if they had used cannabis (marijuana, pot, hash, etc.) in the past 3 months. The possible responses were on a 5-point scale with 0 = *Never*, 1 = *Once or Twice*, 2 = *Monthly*, 3 = *Weekly*, and 4 = *Daily or Almost Daily*.

Heavy Drinking

An index of heavy drinking was derived from a version of the Daily Drinking Questionnaire (DDQ; Collins et al. 1985), which asks participants to report the number of drinks they consume each day of a typical week. The Cronbach's alpha for the DDQ in the screening sample was .78. We summed the number of drinks consumed across 7 days in a typical week. A participant was classified as a heavy drinker if they were male and reported consuming more than 14 drinks per week or were female and reported consuming more than 7 drinks per week, following NIAAA (2004) recommendations for classifying "at risk" drinking.

Results

Missing Data and Attrition

Of the 4640 participants in the baseline/screening sample, 713 (15.4 %) were missing any socio-demographic or psychosocial data, while only 250 (5.4 %) were missing outcome data. Of the 199 individuals in the longitudinal sample at baseline, 159 (80.9 %) were retained at the 12-month follow-up. There were no statistically significant relationships between rates of missing data and substance use (i.e. marijuana, stimulants, heavy drinking) or gambling, the variables of key interest in the present study, suggesting that missing data should not significantly bias the statistical analyses. Nonetheless, a multiple imputation using chained equations approach was utilized to minimize any potential bias due to missing data (Van Buuren et al. 2006). First, ten complete datasets were generated by imputing the missing the missing values in the original dataset. All subsequent analyses were replicated across each of the imputed datasets, with the final results calculated as a pooled average of the ten analyses using Rubin's rules (Rubin 2004).

Cross-Sectional Screening Sample

Substance Use and Gambling Rates

With respect to gambling in the past 6 months, 4.4 % of the screening sampled scored 3 or higher on the South Oaks Gambling Scale, indicating recent problem gambling. With respect to stimulant use, 8.3 % of participants had used stimulants in the past 3 months. Approximately a quarter (23.4 %) of participants engaged in heavy drinking in a typical week and more than a third (35.5 %) had used marijuana in the past 3 months.

Amphetamine and Problem Gambling Associations at Screening

Rates of past 6-month gambling reported at screening for those with recent amphetamine use versus no recent use are reported Table 1. These rates are reported overall and by demographics and substance use. Using bivariate logistic regression, rates of current problem gambling were significantly higher among participants with recent stimulant use (11.1 %) compared with those who did not report recent stimulant use (3.8 %), *OR* 3.16, 95 % *CI* 2.20–4.52, $p < .001$. The higher rates of problem gambling among those with

Table 1 Rates of past 6 months at-risk or problem gambling (SOGS 3 or greater) for recent versus no recent stimulant use by demographics and substance use variables ($N = 4640$)

	All (%)	No recent stimulant use (%)	Recent stimulant use (%)	*OR*	95 % CI	*p*
All participants	4.4 (.3)	3.8 (.3)	11.1 (1.6)	3.16	[2.20, 4.52]	<.001
Gender						
Male	6.7 (.6)	6.0 (.6)	14.1 (2.7)	2.58	[1.60, 4.14]	<.001
Female	2.8 (.3)	2.3 (.3)	8.7 (2.0)	3.96	[2.28, 6.89]	<.001
Race						
Caucasian	3.8 (.4)	3.2 (.4)	1.0 (1.9)	3.18	[2.01, 5.02]	<.001
Asian	5.2 (.6)	4.8 (.6)	12.0 (4.0)	2.39	[1.19, 4.82]	.014
Other	5.2 (.9)	4.2 (.8)	15.0 (4.6)	4.42	[2.14, 9.12]	<.001
Heavy drinking						
No	3.0 (.3)	2.9 (.3)	5.5 (2.0)	1.97	[.90, 4.33]	.090
Yes	9.1 (.9)	7.6 (.9)	14.2 (2.3)	2.00	[1.28, 3.11]	.002
Recent marijuana use						
No	3.0 (.3)	2.9 (.3)	6.6 (3.8)	2.35	[.71, 7.75]	.161
Yes	7.0 (.6)	5.8 (.7)	11.7 (1.8)	2.17	[1.44, 3.27]	<.001

SOGS South Oaks Gambling Screener, *OR* odds ratio, *CI* confidence interval

Table 2 Logistic regression evaluating association between gambling and stimulant use, controlling for relevant demographic and related substance use variables

	Odds ratio	SE	95 % CI	*p*
Demographics				
Female versus male	.38	.06	[.28, .51]	<.001
Race				
Asian versus white	2.10	.36	[1.51, 2.94]	<.001
Other versus white	1.68	.35	[1.11, 2.52]	.014
Other substance use				
Heavy drinker in a typical week	3.02	.56	[2.10, 4.36]	<.001
Past 3-month marijuana use	1.35	.25	[.94, 1.95]	.107
Past 3-month stimulant use	1.75	.36	[1.17, 2.61]	.007

BL baseline, *CI* confidence interval, *B* unstandardized beta, *SE* standard error

Table 3 Descriptive data and inter-correlations for longitudinal sample ($n = 199$)

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	Mean	SE	Range
Demographics														
1. Any intervention												.68	.01	0–1
2. Female versus male	.18											.37	.01	0–1
3. Non-white versus white	–.28	.01										.27	.01	0–1
Substance use														
4. BL stimulant use	.12	.06	–08^									.21	.01	0–1
5. BL marijuana use	–05	–08	–14*	.42*								.65	.01	0–1
6. BL heavy drinking	.17	.10	–23*	.21*	.25*							.58	.01	0–1
Gambling frequency														
7. Baseline	.07	–10*	–04	.10^	.09*	.09*						7.75	.11	0–35
8. 12 months	.07	–07	.15*	.24*	.02	.06	.70*					4.33	.10	0–26
Gambling quantity														
9. Baseline	–09	–05	.10^	.16*	.12*	.05	.58*	.23*				4.59	.05	0–9
10. 12 months	.08	–01	.20*	.23*	.05	.01	.34*	.57*	.92*			2.75	.05	0–9
Gambling problems														
11. Baseline	–04	–04	.01	.03	.01	–03	.42*	.11*	.38*	.04		7.25	.12	1–23
12. 12 months	.03	.06	.15^	.16	–06	.01	.40*	.59*	.50*	.45*	.78*	3.66	.13	0–23

Correlations, means, and standard errors were calculated from the imputed data while ranges are for the non-imputed data

BL baseline, *SE* standard error

^ $p < .1$

* $p < .05$

Table 4 Prospective analysis evaluating association between BL stimulant use and 12-month gambling frequency, quantity, and problems ($n = 199$)

	Gambling frequency			Gambling quantity			Gambling problems		
	B (SE)	95 % CI	*p*	B (SE)	95 % CI	*p*	B (SE)	95 % CI	*p*
Covariates									
BL gambling severity	.33 (.11)	[.12, .55]	.003	.38 (.08)	[.21, .54]	<.001	.35 (.09)	[.17, .54]	<.001
Intervention condition	.13 (.69)	[–1.23, 1.50]	.848	.24 (.39)	[–.54, 1.01]	.544	.21 (.97)	[–1.72, 2.14]	.829
Female versus male	–.31 (.72)	[–1.76, 1.13]	.665	–.05 (.42)	[–.89, .79]	.911	.92 (.90)	[–.87, 2.72]	.310
Race									
Asian versus white	2.16 (.87)	[.44, 3.88]	.014	.80 (.47)	[–.13, 1.74]	.090	2.03 (1.26)	[–.47, 4.53]	.111
Other versus white	.05 (.90)	[–1.75, 1.85]	.957	–.52 (.50)	[–1.54, .49]	.303	–.90 (1.05)	[–2.99, 1.18]	.393
Heavy drinking	.50 (.74)	[–.99, 1.98]	.504	.04 (.41)	[–.77, .84]	.931	.70 (1.07)	[–1.43, 2.84]	.513
Recent marijuana use	–.71 (.75)	[–2.20, .78]	.350	–.15 (.43)	[–1.00, .70]	.733	–1.05 (1.03)	[–3.13, 1.03]	.315
Recent stimulant use	1.75 (.86)	[.05, 3.44]	.043	.82 (.46)	[–.10, 1.75]	.074	1.81 (1.20)	[–.57, 4.19]	.135

BL baseline, *CI* confidence interval, *B* unstandardized beta, *SE* standard error

recent stimulant use was relatively consistent by gender, race, heavy drinking versus no heavy drinking, and recent marijuana versus no recent marijuana.

We further used logistic regression to evaluate the relations between recent stimulant use and problem gambling in the context of relevant covariates. In this model, problem gambling in the past 3 months (SOGS score $\geq$3) was regressed on past 3-month stimulant use, controlling for gender, race/ethnicity, heavy drinking in a typical week, and past 3-month marijuana use. The results of the logistic regression are presented in Table 2. After controlling for demographic variables and other substance use, past 3-month stimulant use was associated with 74 % greater odds (*OR* 1.75, 95 % *CI* 1.17–2.61, $p = .007$) of problem gambling in the past 6 months.

Longitudinal Sample

Baseline Substance Use and Gambling Rates

With respect to gambling in the past 6 months, 64.3 % of the longitudinal sample scored 3 or higher on the South Oaks Gambling Scale at baseline, indicating recent problem gambling. With respect to stimulant use, 21.2 % of participants had used stimulants at baseline. With respect to other substance use, approximately three-fifths (59.2 %) engaged in heavy drinking in a typical week and nearly two-thirds (64.3 %) had used marijuana in the past 3 months. As expected, rates of recent problem gambling, stimulant use, and other substance use were significantly higher in the longitudinal sample than in the screening sample (p's $< .001$).

Means, standard deviations, and bivariate correlations of the demographic, substance use, and gambling variables are presented in Table 3. Overall, gambling frequency, quantity, and consequences declined over time.

Prospective Association Between Stimulant Use and Gambling Outcomes

We used multiple regression to examine the association between baseline stimulant use and 12-month (1) gambling frequency, (2) gambling quantity, and (3) gambling consequences at 12 months. We examined the prospective association between baseline stimulant use and each of the 12-month gambling outcomes in separate models. In each model, the 12-month gambling severity outcome was regressed on the baseline gambling outcome, intervention (i.e. whether the person was assigned to web-based, in-person, or control conditions), baseline recent stimulant use, baseline heavy drinking in a typical week, and baseline recent marijuana use. Intervention group was included in the model as a covariate because individuals in the longitudinal sample were followed as part of an intervention study. The inclusion of the baseline version of the outcome as a covariate enabled a prospective test of the relation between stimulant use and gambling severity. Because gambling outcomes were positively skewed, we applied robust standard error corrections to accommodate non-normal distribution (Huber 1981).

The separate models examining the association of BL recent stimulant use with 12-month gambling outcomes, controlling for intervention condition, gender, race/ethnicity, alcohol use, and marijuana use, are summarized in Table 4. With respect to gambling frequency (Model 1) BL recent stimulant use was associated with a statistically significant increase in gambling frequency at 12 months ($B = 1.75$, $SE = .86$, 95 % *CI* .05–3.44, $p = .043$). With respect to gambling quantity (Model 2), BL recent stimulant use was associated with a marginally significant increase in the amount lost gambling at

12 months ($B = .82$, $SE = .46$, 95 % CI –.10 to 1.75, $p = .074$) after controlling for intervention condition, gender, race/ethnicity, alcohol use, and marijuana use. With respect to gambling consequences (Model 3), the association between BL recent stimulant use and 12-month gambling consequences was not statistically significant ($B = 1.81$, $SE = 1.19$, 95 % CI –.57 to 4.19, $p = .135$).

Discussion

The current study was designed to evaluate concurrent and prospective associations between amphetamine-type stimulant use and problem gambling among college students. We first evaluated the cross-sectional association between recent stimulant use and problem gambling in our general college population. Overall, there was a three-fold higher rate of recent problem gambling among those that had used stimulants versus those that had not used stimulants (11 vs. 4 %) in the past 3 months. We considered the possibility that demographic characteristics or other types of substance use associated with gambling (i.e. heavy drinking or marijuana use) could be driving the greater rates of problem gambling among stimulant users. After controlling for these, recent stimulant use remained significantly associated with problem gambling, predicting a 74 % greater likelihood of problem gambling in the past 6 months. The strong relationship between stimulant use and gambling certainly warrants further study, particularly since motives could differ with simultaneous use (i.e. using stimulants while gambling) compared to concurrent reports of the behaviors (i.e. reporting use of stimulants, reporting use of gambling, yet not necessarily at the same time). With simultaneous use, it is possible that students are seeking to boost alertness or attention from the start, or are trying to offset any perceived barriers to gambling performance from effects of other substances (e.g., using stimulants after heavy alcohol use as a means of feeling less intoxicated, despite no change in actual blood alcohol concentration). With concurrent use, students could be trying to recapture the rush or high they get from gambling, may be seeking to enhance a study session to make up for time lost studying due to gambling, or could reflect personality characteristics related to thrill seeking. Regardless, subsequent research could further examine this relationship.

Next, we evaluated whether baseline stimulant use prospectively predicted changes in three gambling-related outcomes (frequency, quantity, and problems) 12 months later among a high-risk sample of individuals reporting lifetime gambling problems and substance use disorder, and participating in an intervention study. Controlling for baseline gambling severity, gender, drinking, and intervention condition, we found that baseline stimulant use predicted an increased frequency of gambling 12 months later, but not statistically significant differences in gambling-related consequences. Baseline stimulant use was marginally predictive of increased amount of money lost gambling 12 months later. Again, future studies could more thoroughly explore the impact of concurrent versus simultaneous stimulant use with gambling, and, because this has not been a focus of motives-based research, could explore motives for and expectancies surrounding stimulant use as they relate to gambling, if at all.

Clinical Implications

Results of the current study suggest students who use amphetamine-type stimulants are at increased risk for problem gambling. Consistent with prior research on this topic (LaBrie

et al. 2003; Lee et al. 2014), participants in the general college sample who reported using amphetamines had significantly higher odds of engaging in at-risk or probable pathological gambling, even after controlling for other demographic and risk factors including alcohol and marijuana use. In addition, the current study is an important extension of prior research in demonstrating prospective associations between stimulant use at baseline and higher gambling frequency and a trend toward greater amount of money lost gambling 12 months later, even after controlling for known risk and protective factors including gender, race/ethnicity, baseline gambling severity, and alcohol and marijuana use. These findings suggest stimulant use is a risk factor for greater gambling involvement among both general and high-risk samples of college students.

Prior research on comorbidity of stimulant misuse with other addictive behaviors such as marijuana use has suggested students engage in stimulant misuse in an unsuccessful attempt to manage academic consequences associated with their other substance use (Arria et al. 2013). In the context of gambling, it may be that students initially use stimulants in an attempt to enhance gambling performance by increasing alertness while gambling, and/or use stimulants as a coping strategy to deal with poorer academic performance resulting from missing class and/or spending too much time gambling which interferes with studying for exams. This in turn may have the effect of perpetuating students' gambling due to learned associations between stimulant use and gambling and/or disinhibiting effects of amphetamine use on other risk-taking behaviors such as gambling. Additionally, non-medical use of prescription stimulants never intended for the individual could reflect a willingness to take risks that could be mirrored in gambling decisions. In any case, findings suggest interventions which target the concurrent and prospective relationships between problem gambling and amphetamine use are warranted.

Limitations

As with any study, there are limitations that need to be considered when evaluating the results. One of the limitations is the use of self-report measures and concerns regarding potential for under-reporting of stigmatizing behaviors such as gambling or illegal substance use. In order to address this issue, several steps were taken to insure participants knew that the survey was confidential. Participants were informed of steps to protect confidentiality, including the use of a secure encrypted website, identifying all data with a PIN number rather than name, and obtaining a Federal Certificate of Confidentiality. Although this is a potential limitation, research indicates college students are more likely to report sensitive information on computer or web-administered surveys as compared to face-to-face interviews (Miller et al. 2002). Furthermore, extensive prior research in both substance use and gambling demonstrates validity of self-reported stigmatizing behavior under circumstances where participants' confidentiality is assured, there are no real-world consequences for accurately reporting these behaviors, and valid and reliable measures are used (Babor et al. 1987, 2000; Chermack et al. 1998; Darke 1998; LaForge et al. 2005; Marlatt et al. 1998; Smith et al. 1995).

Another limitation is the use of single items to assess marijuana and amphetamine use, and the fact that the amphetamine measure cannot distinguish which specific substance was used. Although the ASSIST is a widely-used screening measure for substance use and related harm (Humeniuk 2006; WHO 2002), the measure uses the term amphetamine to describe the entire class of stimulant drugs, including both legal and illegal substances and those with purely stimulating as well as hallucinogenic effects. The ability to further refine the type of stimulant used, and distinguish between legal, illegal, medical, and non-medical

use of stimulants is an important issue for future research. Despite this limitation, the study did use psychometrically validated measures that have been widely used to assess substance use worldwide.

All data were collected on a single west-coast campus, thus results may not be fully generalizable to the broader population of college students, although the campus is large, demographically diverse, and generally representative of other large west-coast universities. An additional limitation with respect to generalizability is that all participants in the longitudinal sample met criteria for at-risk or probable pathological gambling at baseline and had a concurrent substance use disorder (abuse or dependence). While this is a limitation, the ability to find prospective relationships between baseline stimulant use and gambling behavior 12 months later in this restricted sample suggests the relationship may be even more robust in a general college sample. Furthermore, these prospective analyses (i.e. baseline levels of stimulant use are being used to predict future gambling, controlling for initial levels of gambling) predict whether elevated levels of stimulant use at a snapshot in time predicts change in gambling. While this is not strictly a causal model, since there could be unobserved factors causing that change, with longitudinal data, we can establish temporal precedence of one thing (elevated stimulant use) occurring before the other thing (changes in gambling). Only experimental manipulations can rule out third variable explanations (i.e. "unobserved factors"), thus we suggest a causal pathway, rather than strictly a causal model. Further research needs to establish such experimental models.

Future Directions

Future studies need to utilize a more detailed assessment of what students are reporting related to their substance use. By understanding type of drug use, amount used, and motives associated with use (including motives for comorbid or co-occurring gambling and stimulant use), additional risk factors can be identified, and implications for prevention and intervention can be more thoroughly established. Given the association with numerous other risky behaviors, college counseling centers (who already thoroughly screen for a range of behaviors during intake sessions) could routinely screen for non-medical use of prescription stimulants and other amphetamine use as well as gambling, particularly since students who flag on either (or both) could be experiencing multiple other concerns outside of their presenting issues. Finally, although brief interventions exist for a range of addictive behaviors, future studies could also explore interventions to address comorbid gambling and other substance use. Colleges and universities continue to expand services to support students who may be struggling with a range of health and mental health issue, and also have implemented efforts from screening to strategic outreach to reduce the likelihood of students "slipping through the cracks" when they are dealing with numerous challenges. However, less is in place on campuses to address problem gambling, stimulant use, and, relevant to the current study, their overlap. As the motives behind, consequences of, and trends surrounding these co-occurring behaviors are further examined, campuses can pilot policies, programs, prevention efforts, and interventions to address these emerging issues.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

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

References

Albein-Urios, N., Marinez-Gonzalez, J. M., Lozano, O., & Garcia, A. (2014). Monetary delay discounting in gambling and cocaine dependence with personality comorbidities. *Addictive Behaviors, 39*, 1658–1662.

Albein-Urios, N., Martinez-González, J. M., Lozano, Ó., Clark, L., & Verdejo-García, A. (2012). Comparison of impulsivity and working memory in cocaine addiction and pathological gambling: Implications for cocaine-induced neurotoxicity. *Drug and Alcohol Dependence, 126*, 1–6. doi:10.1016/j.drugalcdep.2012.03.008.

Arria, A. M., Caldeira, K. M., Vincent, K. B., O'Grady, K. E., & Wish, E. D. (2008). Perceived harmfulness predicts nonmedical use of prescription drugs among college students: Interactions with sensation-seeking. *Prevention Science, 9*, 191–201.

Arria, A. M., Wilcox, H. C., Caldeira, K. M., Vincent, K. B., Garnier-Dykstra, L. M., & O'Grady, K. E. (2013). Dispelling the myth of "smart drugs": Cannabis and alcohol use problems predict nonmedical use of prescription stimulants for studying. *Addictive Behaviors, 38*(3), 1643–1650. doi:10.1016/j.addbeh.2012.10.002.

Babor, T. F., Steinberg, K., Anton, R., & Del Boca, F. (2000). Talk is cheap: Measuring drinking outcomes in clinical trials. *Journal of Studies on Alcohol, 61*, 55–63.

Babor, T. F., Stephens, R. S., & Marlatt, G. A. (1987). Verbal report methods in clinical research on alcoholism: Response bias and its minimization. *Journal of Studies on Alcohol, 48*, 410–424.

Barnes, G. M., Welte, J. W., Hoffman, J. H., & Tidwell, M. C. (2010). Comparisons of gambling and alcohol use among college students and noncollege young people in the United States. *Journal of American College Health, 58*, 443–452.

Bhullar, N., Simons, L., Joshi, K., & Amoroso, K. (2012). The relationship among drinking games, binge drinking and gambling activities in college students. *Journal of Alcohol and Drug Education, 56*, 58–84.

Blinn-Pike, L., Lokken Worthy, S., & Jonkman, J. N. (2007). Disordered gambling among college students: A meta-analytic synthesis. *Journal of Gambling Studies, 23*, 175–183.

Chermack, S., Singer, K., & Beresford, T. (1998). Screening for alcoholism among medical inpatients: How important is corroboration of patient self-report? *Alcoholism: Clinical and Experimental Research, 22*, 1393–1398.

Collins, R. L., Parks, G. A., & Marlatt, G. A. (1985). Social determinants of alcohol consumption: The effects of social interaction and model status on the self-administration of alcohol. *Journal of Consulting and Clinical Psychology, 53*, 189–200.

Darke, S. (1998). Self-report among injecting drug users: A review. *Drug and Alcohol Dependence, 51*, 253–263.

Dubé, D., Freeston, M. H., & Ladouceur, R. (1996). Potential and probable pathological gamblers: Where do the differences lie? *Journal of Gambling Studies, 12*(4), 419–430. doi:10.1007/BF01539186.

Engwall, D., Hunter, R., & Steinberg, M. (2004). Gambling and other risk behaviors on university campuses. *Journal of American College Health, 56*, 245–255.

Gupta, R., & Derevensky, J. L. (2000). Adolescents with gambling problems: From research to treatment. *Journal of Gambling Studies, 16*, 315–342.

Hall, G. W., Carriero, N. J., Takushi, R. Y., Montoya, I. D., Preston, K. L., & Gorelick, D. A. (2000). Pathological gambling among cocaine-dependent outpatients. *American Journal of Psychiatry, 157*, 1127–1133. doi:10.1176/appi.ajp.157.7.1127.

Huber, P. (1981). *Robust statistics*. New York, NY: Wiley.

Humeniuk, R. (2006). *Validation of the alcohol, smoking and substance involvement screening test (ASSIST) and pilot brief intervention [electronic resource]: a technical report of phase II findings of the WHO ASSIST project*, WHO ASSIST Phase II Study Group.

Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Schulenberg, J. E. (2007). *Monitoring the future national survey results on drug use, 1975–2006. College students and adults ages, 19–45, Vol. II*. Ann Arbor: Institute for Social Research, The University of Michigan.

Johnston, L. D., O'Malley, P. M., Miech, R. A., Bachman, J. G., & Schulenberg, J. E. (2015). *Monitoring the future national survey results on drug use, 1975–2014: Overview, key findings on adolescent drug use*. Ann Arbor: Institute for Social Research, The University of Michigan.

LaBrie, R. A., Shaffer, H. J., LaPlante, D. A., & Wechsler, H. (2003). Correlates of college student gambling in the United States. *Journal of American College Health, 52*, 53–62.

Laforge, R. G., Borsari, B., & Baer, J. S. (2005). The utility of collateral informant assessment in college alcohol research: Results from a longitudinal prevention trial. *Journal of Studies on Alcohol, 66*, 479–487.

Larimer, M. E., Lee, C. M., Kilmer, J. R., Fabiano, P., Stark, C., Geisner, I. M., et al. (2007). Personalized mailed feedback for drinking prevention: One year outcomes from a randomized clinical trial. *Journal of Consulting and Clinical Psychology, 75*, 285–293.

Lee, G. P., Ghandour, L. A., Takache, A. H., & Martins, S. S. (2014). Investigating the association between strategic and pathological gambling behaviors and substance use in youth: could religious faith play a differential role? *American Journal of Addiction, 23*, 280–287. doi:10.1111/j.1521-0391.2014.12101.x.

Lesieur, H. R., & Blume, S. B. (1987). The South Oaks Gambling Screen (SOGS): A new instrument for the identification of pathological gamblers. *American Journal of Psychiatry, 144*, 1184–1188.

Lorains, F., Cowlishaw, S., & Thomas, S. (2011). Prevalence of comorbid disorders in problem and pathological gambling: Systematic review and meta-analysis of population surveys. *Addiction, 106*, 490–498.

Marlatt, G. A., Baer, J. S., Kivlahan, D. R., Dimeff, L. A., Larimer, M. E., Quigley, L. A., et al. (1998). Screening and brief intervention for high-risk college student drinkers: Results from a two-year follow-up assessment. *Journal of Consulting and Clinical Psychology, 66*, 604–615.

Martens, M., Rocha, T., Cimini, D., Diaz-Myers, A., Rivero, E., & Wulfert, E. (2009). The co-occurrence of alcohol use and gambling activities in first-year college students. *Journal of American College Health, 57*, 597–602.

Martin, R. J., Usdan, S., Cremeens, J., & Vail-Smith, K. (2014). Disordered gambling and co-morbidity of psychiatric disorders among college students: An examination of problem drinking, anxiety and depression. *Journal of Gambling Studies, 30*, 321–333.

McCabe, S. E., Boyd, C. J., & Teter, C. J. (2009). Subtypes of nonmedical prescription drug misuse. *Drug and Alcohol Dependence, 102*, 63–70.

McCabe, S. E., Cranford, J. A., Morales, M., & Young, A. (2006). Simultaneous and concurrent poly-drug use of alcohol and prescription drugs: Prevalence, correlates and consequences. *Journal of Studies on Alcohol, 67*, 529–537.

McCabe, S. E., Knight, J. R., Teter, C. J., & Wechsler, H. (2005). Nonmedical use of prescription stimulants among US college students: Prevalence and correlates of a national survey. *Addiction, 100*, 96–106.

McCabe, S. E., & Teter, C. J. (2007). Drug use related problems among nonmedical users of prescription stimulants: A web-based survey of college students from Midwestern University. *Drug and Alcohol Dependence, 91*, 69–76.

McCabe, S. E., West, B. T., & Wechsler, H. (2007). Trends and college-level characteristics associated with the nonmedical use of prescription drugs among US college students from 1993–2001. *Addiction, 102*, 455–465.

Miller, E. T., Neal, D. J., Roberts, L. J., Baer, J. S., Cressler, S. O., Metrik, J., & Marlatt, G. A. (2002). Test-retest reliability of alcohol measures: Is there a difference between Internet-based assessment and traditional methods. *Psychology of Addictive Behaviors, 16*, 56–63.

National Institute on Alcohol Abuse and Alcoholism. (2004). *Helping patients with alcohol problems: A health practitioner's guide*. Bethesda, MD: National Institute on Alcohol Abuse and Alcoholism.

Neighbors, C., Lostutter, T. W., Larimer, M. E., & Takushi, T. (2002). Measuring gambling outcomes among college students. *Journal of Gambling Studies, 18*, 339–360.

Nowak, D. E., & Aloe, A. M. (2014). The prevalence of pathological gambling among college students: A meta-analytic synthesis, 2005–2013. *Journal of Gambling Studies, 30*(4), 819–843.

Rabiner, D. L., Anastopoulos, A. D., Castello, E. J., Hoyle, R. H., McCabe, S. E., & Swartzwelder, H. S. (2009a). The misuse and diversion of prescribed ADHD medications by college students. *Journal of Attention Disorder, 13*, 144–153.

Rabiner, D. L., Anastopoulos, A. D., Costello, E. J., Hoyle, R. H., McCabe, S. E., & Swartzwelder, H. S. (2009b). Motives and perceived consequences of nonmedical ADHD medication use by college students: Are students treating themselves for attention problems? *Journal of Attention Disorders, 13*, 259–270.

Rosenthal, R. J., & Lorenz, V. C. (1992). The pathological gambler as criminal offender: Comments on evaluation and treatment. *Psychiatric Clinics of North America, 15*, 647–660.

Rubin, D. B. (2004). Direct and indirect causal effects via potential outcomes. *Scandinavian Journal of Statistics, 31*, 161–170. doi:10.1111/j.1467-9469.2004.02-123.x.

Shaffer, H. J., & Hall, M. N. (2001). Updating and refining prevalence estimates of disordered gambling behaviour in United States and Canada. *Canadian Journal of Public Health, 92*(3), 169–172.

Skinner, H. (1982). The drug abuse screening test. *Addictive Behaviors, 7*, 363–371.
Smith, G., McCarthy, D., & Goldman, M. (1995). Self-reported drinking and alcohol-related problems among early adolescents: Dimensionality and validity over 24 months. *Journal of Studies on Alcohol, 56*, 383–394.
Stuhldreher, W. L., Stuhldreher, T. J., & Forrest, K. Y. (2007). Gambling as an emerging health problem on campus. *Journal of American College Health, 56*, 75–88.
Substance Abuse and Mental Health Administration (SAMHSA). (2003). *Emergency department trends from the drug abuse warning network final estimates, 1995–2002 DAWN series: D-24*. Rockville, MD: Office of Applied Studies.
Substance Abuse and Mental Health Administration (SAMHSA). (2004). *Results from the 2003 national survey on drug use and health: National findings*. Rockville, MD: Office of Applied Studies.
Teter, C. J., McCabe, S. E., Boyd, C. J., & Guthrie, S. K. (2003). Illicit methylphenidate use in an undergraduate student sample: Prevalence and risk factors. *Pharmacotherapy, 23*, 609–617.
Thombs, D. L., Ray-Tomasek, J., Osborn, C. J., & Olds, R. S. (2005). The role of sex-specific normative beliefs in undergraduate alcohol use. *American Journal of Health Behavior, 29*, 342–351.
Turrisi, R., Larimer, M., Mallett, K., Kilmer, K., Ray, A., Mastroleo, N., et al. (2009). A randomized clinical trial evaluating a combined intervention for high-risk students. *Journal of Studies on Alcohol and Drugs, 70*, 555–567.
Van Buuren, S., Brand, J. P. L., Groothuis-Oudshoorn, C. G. M., & Rubin, D. B. (2006). Fully conditional specification in multivariate imputation. *Journal of Statistical Computation and Simulation, 76*, 1049–1064. doi:10.1080/10629360600810434.
WHO Assist Working Group. (2002). The alcohol, smoking and substance involvement screening test (ASSIST): Development, reliability and feasibility. *Addiction, 97*, 1183–1194.
Zack, M., & Poulos, C. X. (2003). Amphetamine primes motivation to gamble and gambling-related semantic networks in problem gamblers. *Neuropsychopharmacology, 29*(1), 195–207. doi:10.1038/sj.npp.1300333.
Zack, M., & Poulos, C. X. (2009). Parallel roles for dopamine in pathological gambling and psychostimulant addiction. *Current Drug Abuse Reviews, 2*(1), 11–25. doi:10.2174/1874473710902010011.