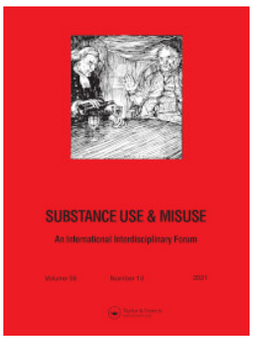

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ORIGINAL ARTICLE

Patterns, Consequences, and Motives in Simultaneous Use of Prescription Stimulant Medication with Alcohol and Marijuana

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ABSTRACT

Objective: Nonmedical use of prescription stimulants (NPS) continues to be a concern on college campuses. Previous research demonstrates a strong link between NPS and use of other substances, particularly alcohol and marijuana among college students. Simultaneous use of NPS with other substances has become an increasing concern. Given the high rates of NPS and simultaneous NPS with other substances, research examining substance use patterns and motives among students is warranted. *Method:* This study evaluated group differences in alcohol and marijuana use patterns, consequences, and motives among college students: a) with no NPS history (No NPS); b) engaged in NPS with no simultaneous use (Non-Sim NPS); and c) engaged in simultaneous NPS with alcohol and/or marijuana (Sim NPS). Participants included 1,108 students from three universities who reported past-year marijuana and alcohol use. *Results:* Overall, 32.8% reported lifetime NPS with 12.5% indicating NPS in the previous 3 months, of which 51.1% reported simultaneous NPS with alcohol and 40.2% with marijuana. Significant group differences for all drinking and marijuana outcomes were found, with heaviest rates among the Sim NPS group, followed by the Non-Sim NPS group, and the No NPS group. The Sim NPS group reported greater motives for using marijuana to alter the effects of other substances. *Conclusions:* College students engaged in simultaneous NPS with alcohol and marijuana are a high-risk group that should be the focus of prevention and intervention programs in the campus setting.

KEYWORDS
Prescription stimulants; alcohol; marijuana; motives

Introduction

As universities increase their substance use prevention efforts, college students' use of (and, at times, struggles with) non-medical prescription stimulants is gaining attention. Prescription stimulants have a high abuse potential, particularly among college students and adolescents (Schulenberg et al., 2020; McCabe et al., 2006a, 2015; Substance Abuse and Mental Health Services Administration (SAMHSA), 2017). While these drugs can be used safely with a prescription, non-medical use can be associated with a range of physical impacts varying in severity, including increased blood pressure and heart rate, increased respiratory rate, high body temperatures, risk of seizures, psychosis, paranoia, and overdose (National Institute on Drug Abuse, 2018). In the Monitoring the Future (MTF) study, 2019 data indicated that 13.5% of college students report lifetime non-medical prescription stimulant use (NPS) (defined as use not under a doctor's order), with 8.4% reporting past-year Adderall and 2.5% reporting past-year Ritalin use (Schulenberg et al., 2020). A meta-analysis estimated that 17% of college students have engaged in NPS, but acknowledged that rates vary widely depending on geographic, demographic, and academic differences among colleges (Benson et al., 2015).

Studies examining NPS correlates have found that rates are highest among college students attending more competitive universities and who are white and reside in Greek-affiliated housing (Schulenberg et al., 2020; McCabe et al., 2005, 2014). NPS is strongly linked to other forms of substance use, particularly alcohol and marijuana use. Relative to other students, those who engage in NPS are more likely to report consuming any alcohol, engaging in frequent heavy episodic drinking episodes, drinking to get drunk, driving after a heavy drinking episode, being a passenger with a drunk driver and meeting criteria for an alcohol use disorder (Kilmer et al., 2021; McCabe et al., 2005, 2006a, 2007; Rabiner et al., 2009b; Teter et al., 2003). McCabe et al. (2006a) examined rates of co-occurring non-medical use of prescription medications and past-year drinking behaviors in a national sample and found that rates of NPS were approximately five times higher (11% versus 2%) among those 18–24 years old who met DSM-IV criteria for alcohol abuse or dependence versus those who did not.

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Similarly, research has demonstrated links between marijuana use and NPS (Arria et al., 2013; Kilmer et al., 2021; McCabe et al., 2005); for example, 86% of students who engaged in NPS also reported marijuana use, compared to 39% of NPS abstainers (Kilmer et al., 2021).

When considering polysubstance use, researchers frequently distinguish concurrent use (i.e., reporting use of more than one substance, but not necessarily at the same time nor such that the effects overlap) and simultaneous use (i.e., reporting use of more than one substance such that the effects overlap). Use of substances simultaneously can introduce drug interactions, ranging from excessive CNS depression to antagonistic reactions (Seamon et al., 2007), and given the overlap between NPS, alcohol, and marijuana users, simultaneous use of all three substances may contribute to even greater psychopharmacological risk. The limited research examining acute drug interactions with prescription stimulants has shown that co-ingestion with alcohol can lead to increased risk of overdose (Markowitz et al., 1999), emergency room visits (Baggio et al., 2014), impaired driving, and fatal traffic accidents (Bogstrand et al., 2012; Li et al., 2013; Ramaekers et al., 2012) and co-ingestion with marijuana can increase heart rate and increase emergency room visits (Kollins et al., 2015; (SAMHSA), 2013). Despite these preliminary findings, few studies have examined the prevalence and correlates of simultaneous use of prescription stimulants with alcohol or marijuana; those that do often have limitations related to small sample sizes or minimal assessment/measurement of factors surrounding this high-risk practice.

Considering the potential risks posed by co-using stimulants with alcohol and marijuana, rates of such co-use among college students are alarmingly high. Brandt et al. (2014) found that among college students who had engaged in lifetime NPS, 41.8% reported mixing them with other drugs, with 86.8% of them reporting use with marijuana and 81.6% with alcohol. Similarly, a study of students from eight college campuses in North Carolina found that among the 4.9% who reported past-year NPS, 46.4% also reported simultaneous use with alcohol (Egan et al., 2013). Egan et al. (2013) further found that those with past-year simultaneous NPS and alcohol use (compared to those with alcohol use only) had lower grade point averages, were 2.6 times more likely to report heavy episodic drinking, were 2.7 times more likely to be current marijuana users, and were 3.8 times more likely to have other current illicit drug use (besides marijuana and NPS). Additionally, those with simultaneous NPS and alcohol use, compared to only alcohol use, were twice as likely to experience severe negative consequences and 5.3 times more likely to experience moderate consequences (Egan et al., 2013).

Thus, understanding the factors that may influence simultaneous NPS and other substance use is of critical importance. Students engaged in NPS predominantly report motives related to improving academic performance (Blevins et al., 2017; Fond et al., 2016; Garnier-Dykstra et al., 2012; Parks et al., 2017; Rabiner et al., 2009a; Thiel et al., 2019). However, some students report engaging in NPS for recreational purposes (e.g., staying awake longer to party; getting high). Rabiner et al. (2009a) found that 12% of students engaged in NPS reported intending to prolong the intoxicating effects of alcohol or other substances at least some of the time, and 16% indicated using to get high at least some of the time (also see Garnier-Dykstra et al. Garnier-Dykstra et al., 2012). While some students may engage in NPS for the purpose of enhancing the effects of alcohol or marijuana or use alcohol or marijuana to increase the high from NPS (Kollins et al., 2015), it is also possible that some students use other drugs to counteract or "come down" off of stimulants. For example, marijuana may subjectively lessen sleep difficulties often experienced as a result of NPS due to marijuana's impact on the onset of sleep (Angarita et al., 2016; Rabiner et al., 2009a).

Given that motives are proximal predictors of alcohol and marijuana use (Kuntsche et al., 2005) and that students engaged in NPS also use these substances at higher rates, elucidating the motives for substance use is essential for identifying students at risk of experiencing negative consequences. Cooper's (1994) four-factor model of drinking motives has been extensively studied in the alcohol literature. In this model, social motives involve reasons to drink associated with social facilitation; enhancement motives capture reasons associated with fun and pleasure; coping motives indicate drinking to reduce negative affect; and conformity motives relate to drinking to fit-in with peers. Social and enhancement motives are more often endorsed than coping and conformity motives (Cooper et al., 2016; Kuntsche et al., 2005). In general, social motives are associated with moderate alcohol use, enhancement motives with heavy drinking, and coping motives with heavier drinking and alcohol-related problems (Cooper et al., 2016; Kuntsche et al., 2005). Findings for conformity motives have been less consistent (Cooper et al., 2016; Kuntsche et al., 2005). Enhancement motives are most strongly endorsed for marijuana followed by social motives (Cooper et al., 2016). Although less frequently endorsed, marijuana coping motives have been related to more frequent marijuana use and negative consequences (Bonn-Miller et al., 2007; Buckner, 2013; Cooper et al., 2016).

Importantly, research has not previously examined whether students who engage in NPS differ in terms of their specific motivations for alcohol and marijuana use. Furthermore, differences in patterns of alcohol and marijuana use and consequences between students engaging in versus abstaining from simultaneous NPS are unknown. The purpose of the present study was to evaluate group differences in patterns of alcohol and marijuana use and related consequences as well as motives for using alcohol and marijuana among a) students with no lifetime NPS history (No NPS); b) students engaged in NPS with no simultaneous use (Non-Sim NPS); and c) students engaged in NPS who use them simultaneously with alcohol and/or marijuana (Sim NPS). We hypothesized that the Sim NPS group would report the heaviest rates of use and consequences, followed by the Non-Sim NPS group, and then the No NPS group. Because simultaneous use of alcohol and marijuana is often associated with enhancement motives (e.g., to get a better high or to increase positive effects) (Patrick et al., 2018), we also hypothesized that students in the Sim NPS group

would report more enhancement motives for alcohol and marijuana use as well as motives for using alcohol and marijuana to either increase or decrease the effects of other substances than students in the other groups.

Method

All procedures were approved by the coordinating university institutional review board. An NIH Certificate of Confidentiality was obtained to protect participant confidentiality.

Design and sample

To determine eligibility, we screened students from three state universities with (a) legal medical marijuana in all three states, but (b) differing state laws regarding "recreational" (or non-medical) marijuana use: School A was in a state where non-medical marijuana use was criminalized; School B was in a state where non-medical marijuana use was decriminalized; and School C was in a state where non-medical marijuana use was legal at age 21. In October 2017, 8,000 students from each university ($N = 24{,}000$) were randomly selected from each school's registrar database and were sent an email invitation to the screening survey. Screening survey completers were entered into a lottery to win one of ten $100 Amazon.com gift cards at each campus. Screening survey participants were fairly representative of the invited sample based on registrar demographic characteristics (see White et al., 2019 for details).

Of those who completed screening, 2,874 students met criteria for the baseline survey, which included being a full-time student on the registrar list at one of the three universities, between ages 18 and 24 and having used alcohol and marijuana in the previous year. Of the 2,874 eligible students, we invited a stratified by school random sample of 2,501 students to take the online baseline survey. Past-month alcohol and marijuana users were over-sampled to ensure enough of the target sample for a subsequent phase of the study involving daily data collection.

A total of 1,524 students (60.9% of those invited) completed the baseline survey within the required five-day window. Of those, 1,390 students provided valid data (survey completion and confirmation of eligibility). No participants failed attention items ensuring they were providing valid responses. Participants were 62.4% female with a mean age of 19.8 ($SD = 1.3$); 63.8% were white students, 12.5% were Asian, 2.7% Black/African American, 0.1% Native American, 0.2% Asian Pacific, 0.1% other, 1.7% more than one race, and 12.2% reported Hispanic/Latinx ethnicity. Students were 20.9% freshmen, 24.8% sophomores, 23.5% juniors, and 29.9% seniors. (For greater detail on recruitment, see White et al. 2019).

Measures

NPS

Consistent with the Monitoring the Future study (Schulenberg et al., 2020), lifetime NPS was assessed with one item: "Have you ever used Adderall or Ritalin without doctor's orders?" Participants who indicated lifetime NPS were then asked whether they had engaged in NPS in the past 3 months and past 30 days.

Simultaneous NPS

Among students reporting lifetime NPS, simultaneous NPS with alcohol and marijuana were assessed with one item each: "When you drink/use marijuana, how often do you use alcohol/marijuana with Adderall or Ritalin?" Responses ranged from 0 = Never to 4 = Weekly or more often. To create NPS groups, we first eliminated anyone who reported lifetime Adderall/Ritalin use but did not engage in NPS in the past 3 months ($N = 282$). The remaining participants ($N = 1108$) were included in the analytic sample. Of these participants, 934 were lifetime abstainers. Among those who engaged in NPS in the past 3 months ($N = 174$), 104 never used alcohol with NPS, 42 used less than monthly, 16 used monthly, 9 used more than monthly but less than weekly, and 3 used weekly or more often; among this same group 85 never used NPS with marijuana, 60 used less than monthly, 13 monthly, 11 more than monthly but less than weekly, and 5 used weekly or more often. Given the small numbers of those engaged in simultaneous NPS with alcohol or marijuana, we dichotomized simultaneous use into any vs. no simultaneous use. The final NPS groups were: no NPS history (No NPS; $n = 934$), NPS without simultaneous alcohol or marijuana use (Non-Sim NPS; $n = 66$), and simultaneous NPS with alcohol and/or marijuana (Sim NPS; $n = 108$). When examining alcohol and marijuana outcomes, the Sim NPS group was substance specific (see Data Analysis section below).

Alcohol use

Past 3-month frequency of alcohol use was scored on an 8-point ordinal scale ranging from no drinking to daily drinking, with responses recoded to number of days used (ranging from 0 to 90). We computed the total weekly number of drinks consumed based on drinks reported for each day on a typical week in the last month from the Daily Drinking Questionnaire (DDQ; Collins et al., 1985). Students also reported on the number of past 30-day heavy episodic drinking days (HED; 4+ drinks for women or 5+ drinks for men during a single drinking occasion; Wechsler et al., 2000).

Marijuana use

Past 3-month marijuana use frequency was assessed on the same scale as alcohol frequency (ranging from 0 to 90 days). Total number of hours spent high on marijuana products per week was assessed using a modified version of the DDQ.

Consequences

Students indicated whether or not they experienced 28 consequences in the past 3 months because of using alcohol

and because of using marijuana. Items were selected from the Brief Young Adult Alcohol Consequence Questionnaire (BYAACQ; Kahler et al., 2005) and the Brief Marijuana Consequences Questionnaire (B-MACQ; Simons et al., 2012) without duplication of any specific item. Both scales have been validated with college students (Kahler et al., 2005; Simons et al., 2012).

Motives

Students completed the social, enhancement, and coping subscales from the Drinking Motives Questionnaire-Revised (DMQ-R; Cooper, 1994) and Marijuana Motives Measure (MMM; Simons et al., 1998, 2000). We did not include the conformity motives subscale due to its poorer predictive validity in college samples (Cooper et al., 2016) and to reduce participant burden. We also did not include the expansion motives subscale from the MMM to reduce participant burden. These measures ask participants how often (*1* = Almost never/never, *2* = Some of the time, *3* = Half of the time, *4* = Most of the time, *5* = Almost always/always) they used a substance for a given reason. Each subscale includes five items and identical items were asked for alcohol and marijuana. Cronbach's alphas ranged from .81-.87 for drinking subscales and .88-.91 for marijuana subscales. Additional single items (with the same response scale) assessed motives for using alcohol and marijuana "to increase the effects of some other drug(s)", "to decrease the effects of some other drug(s)", and "to get sleep" taken from an assessment of motives for simultaneous use (Patrick et al., 2018).

Covariates

Age was measured continuously from 18 to 24. Sex was coded 1 for males and 0 for females. Racial/ethnic background was coded 1 for non-Hispanic white and 0 for other racial/ethnic backgrounds. School was included as dummy coded variables with School C as the reference group. A composite variable was created for other substance use (i.e., heroin, opiates other than heroin, crystal meth, sedatives/tranquilizers, cocaine/crack, designer drugs [e.g., ecstasy, MDMA etc.], hallucinogens, and inhalants) summing the number of other drugs used in the previous 3 months (ranging from 0 to 4 in this sample).

Data analysis

We used chi-square and analyses of variance (ANOVAs) to compare students in the No NPS, Non-Sim NPS, and Sim NPS groups across demographic characteristics. Analyses of covariance (ANCOVAs) were conducted to examine group differences in alcohol use (past 3-month alcohol use frequency, number of drinks consumed per week, past 30-day HED episodes) and related negative consequences, marijuana use (frequency and weekly hours high) and related negative consequences, and motives for using alcohol and marijuana. The Sim NPS groups for these ANCOVAs were substance specific (i.e., for alcohol outcomes, the Sim NPS group included those who engaged in simultaneous NPS with alcohol [$n = 80$]; for marijuana outcomes, the Sim NPS group included those who engaged in simultaneous NPS with marijuana [$n = 70$]). Demographic characteristics (age, sex, race/ethnicity), school, number of other substances used in the past 3 months, and frequency of use of the other substance (alcohol for marijuana outcomes and marijuana for alcohol outcomes) were included as covariates in each model. Models examining substance use-related consequences also controlled for use frequency of the corresponding substance (i.e., alcohol frequency for alcohol consequences and marijuana frequency for marijuana consequences). Models examining alcohol and marijuana motives controlled for both alcohol and marijuana use frequency.

A Bonferroni correction accounting for family-wise error across all alcohol (4), marijuana (3), and motives (12) models was used to evaluate statistical significance for the omnibus ANCOVA analyses (i.e., $\alpha = 0.05/19 = 0.0026$). In addition, we used a Bonferroni correction to account for the three post-hoc pairwise comparisons in each model (i.e., $\alpha = 0.05/3 = 0.0167$) when the omnibus test was significant.

Results

Prevalence of NPS and simultaneous NPS

Overall, 32.8% of the sample reported ever engaging in NPS, 12.5% reported past 3-month use, and 9.8% reported past 30-day use. Of those reporting NPS in the past 3 months, 51.2% reported using NPS simultaneously with alcohol and 40.2% with marijuana.

Descriptive statistics

Tables 1 and 2 provides descriptive information and χ^2 statistics (Table 1) and ANOVA results (Table 2) comparing NPS subgroups. Groups differed significantly on all demographic characteristics. Members of the Sim NPS group were older and more likely to be male and non-Hispanic white. Rates of Sim NPS varied by campus with the highest rates at School B (decriminalized), followed by School A (criminalized) and School C (legal).

Alcohol use and related problems

There were significant main effects of NPS status on frequency of drinking, total weekly number of drinks, HED episodes, and alcohol-related negative consequences, controlling for school, age, sex, race/ethnicity, number of other drugs used, and marijuana frequency for all models and also controlling for alcohol frequency for the consequence model (Table 3). The Sim NPS group and Non-Sim NPS group reported more frequent past 3-month alcohol use than the No NPS group, but did not differ significantly from each other. Moreover, the Sim NPS group reported greater drinks per week and more HED episodes than either the Non-Sim NPS group or the No NPS group. The Sim NPS group experienced more alcohol-related consequences

Table 1. Descriptive frequencies by NPS group.

	Total (*N* = 1,108) n (%)	**No NPS** (*n* = 934) n (%)	**Non-Sim NPS** (*n* = 66) n (%)	**Sim NPS** (*n* = 108) n (%)	χ2 value
Sex					
Male	404 (36.5%)	322 (34.5%)	27 (40.9%)	55 (50.9%)	11.91**
Female	704 (63.5%)	612 (65.5%)	39 (59.1%)	53 (49.1%)	
Race					
White	759 (68.6%)	618 (66.2%)	48 (72.7%)	93 (86.1%)	18.30***
Nonwhite	348 (31.4%)	315 (33.8%)	18 (27.3%)	15 (13.9%)	
School					
School A	345 (31.1%)	294 (31.5%)	20 (30.3%)	31 (28.7%)	17.33**
School B	382 (34.5%)	300 (32.1%)	29 (43.9%)	53 (49.1%)	
School C	381 (34.4%)	340 (36.4%)	17 (25.8%)	24 (22.2%)	

Note. For these analyses, the Sim NPS group included participants who indicated past 3-month NPS and used alcohol and/or marijuana simultaneously with prescription stimulants. School A is in a state where recreational marijuana use is criminalized; School B is in a state where recreational marijuana use is decriminalized; School C is in a state where recreational marijuana use is legal for adults.

***$p<.001$;

**$p<.01$;

*$p<.05$.

Table 2. NPS group differences in age and other substances used.

	Overall Mean (SD)	**No NPS** Mean (SD)	**Non-Sim NPS** Mean (SD)	**Sim NPS** Mean (SD)	*df*	F
Age	19.72 (1.31)	19.67[a] (1.31)	19.73[a] (1.18)	20.22[b] (1.27)	2	29.81***
Other Substances Used	0.23 (0.61)	0.11[a] (0.37)	0.53[b] (0.96)	1.07[c] (1.07)	2	171.03***

Note. For these analyses, the Sim NPS group included participants who indicated past 3-month NPS and used alcohol and/or marijuana simultaneously with prescription stimulants. Within each row, means followed by different letters differ significantly ($p<.05$) from each other.
***$p<.001$;
**$p<.01$;
*$p<.05$.

than the No NPS group, but did not differ significantly from the Non-Sim NPS group. In addition, the Non-Sim NPS group reported more frequent drinking, drinks per week, and HED episodes than the No NPS group. Overall, effect sizes were small to moderate for total weekly number of drinks and HED episodes and small for consequences and past 3-month frequency.

Marijuana use and related problems

There were significant main effects of NPS status on past 3-month frequency of marijuana use, total number of hours spent high in a typical week, and number of marijuana-related consequences controlling for covariates (Table 3). Students who engaged in Sim NPS reported more frequent marijuana use and spent more hours high in a typical week than either the Non-Sim NPS or No NPS groups. The Sim NPS group experienced more marijuana-related consequences than the No NPS group, controlling for frequency of use and the other covariates, but did not significantly differ from the Non-Sim NPS group. Effect sizes were small to moderate for hours high and small for frequency and marijuana consequences.

Motives

Results from the ANCOVAs examining NPS group differences in motives are presented in Table 4. There were no significant main effects of NPS status on motives for using alcohol to increase or decrease the effects of another substance. However, there were significant main effects of NPS status on motives for using marijuana to both increase and decrease the effects of another substance. Students who engaged in Sim NPS, compared to the No NPS group, reported greater motives for using marijuana to increase the effects of another substance, but did not differ from the Non-Sim NPS group. Students who engaged in Sim NPS and Non-Sim NPS reported using marijuana to decrease the effects of another substance more than the No NPS group, but did not differ from each other. Nonetheless, effects sizes for the significant models were relatively small. There was no significant main effect of NPS status on enhancement, social, coping, or sleep motives for drinking or for using marijuana.

Discussion

Consistent with our first hypothesis, the Sim NPS group consumed alcohol more frequently, reported more drinks per week, reported more instances of HED, and reported experiencing more alcohol-related negative consequences than those in the No NPS group. However, the Sim NPS group did not significantly differ from the Non-Sim NPS group in terms of alcohol use frequency or experience of consequences. As with previous studies (Kilmer et al., 2021; McCabe et al., 2005, 2006a, 2007; Rabiner et al., 2009b;

Table 3. NPS group differences in alcohol and marijuana use and related problems.

	df	F	*P*	Partial η2	**No NPS** Mean (SD)	**Non-Sim NPS** Mean (SD)	**Sim NPS** Mean (SD)
Alcohol Variables					*n* = 934	*n* = 85	*n* = 89
Past 3 Month Frequency	2	15.50	<.001	.027	12.77[a] (13.58)	21.18[b] (15.02)	29.06[b] (18.65)
Drinks Per Week	2	36.06	<.001	.062	7.51[a] (7.14)	12.96[b] (9.48)	19.64[c] (13.67)
Past 30 Day HED Drinking Episodes	2	33.32	<.001	.057	2.56[a] (3.15)	4.44[b] (4.17)	6.91[c] (4.40)
Negative Consequences	2	9.49	<.001	.017	5.03[a] (4.41)	6.84[ab] (5.23)	9.04[b] (4.89)
Marijuana Variables					*n* = 934	*n* = 104	*n* = 70
Past 3 Month Frequency	2	15.43	<.001	.027	16.00[a] (26.63)	32.61[a] (32.63)	49.07[b] (34.52)
Average Weekly Hours High	2	23.33	<.001	.041	5.71[a] (9.22)	10.53[a] (12.27)	19.67[b] (18.51)
Negative Consequences	2	7.56	<.001	.014	2.34[a] (3.39)	4.19[ab] (3.89)	6.07[b] (5.14)

Note. The Bonferroni adjusted criterion *p*-value for each omnibus ANCOVA was *p*<.0026. Means followed by different letters differ significantly from each other at Bonferroni adjusted *p*<.0167. Models control for age, sex, race/ethnicity, school attended, number of other substances used in the past 3 months, and frequency of other substance used (alcohol for marijuana outcomes and marijuana for alcohol outcomes). Models for consequences also control for frequency of the corresponding substance (e.g., alcohol frequency for alcohol consequences and marijuana frequency for marijuana consequences). Sim NPS refers to simultaneous NPS with alcohol use for alcohol outcomes and simultaneous NPS with marijuana use for marijuana outcomes.

Table 4. NPS group differences in alcohol and marijuana use motives.

	df	F	*p*	Partial η2	**No NPS** Mean (SD)	**Non-Sim NPS** Mean (SD)	**Sim NPS** Mean (SD)
Increasing/decreasing effects of another substance motives							
Alcohol - To increase effects	2	1.24	.288	.002	1.27 (0.69)	1.64 (1.03)	1.60 (0.85)
Alcohol - To decrease effects	2	3.85	.022	.007	1.07 (0.38)	1.20 (0.58)	1.30 (0.59)
Marijuana - To increase effects	2	6.78	<.001	.012	1.28[a] (0.74)	1.63[a] (1.00)	2.04[b] (1.29)
Marijuana - To decrease effects	2	15.06	<.001	.027	1.13[a] (0.48)	1.47[b] (0.85)	1.74[b] (1.07)
Sleep motives							
Alcohol	2	2.37	.094	.004	1.17 (0.56)	1.11 (0.31)	1.17 (0.48)
Marijuana	2	1.63	.197	.003	1.83 (1.21)	2.44 (1.36)	2.99 (1.41)
Enhancement motives							
Alcohol	2	2.57	.077	.005	15.27 (5.26)	16.85 (5.42)	18.29 (4.60)
Marijuana	2	0.06	.945	.001	15.28 (6.41)	17.28 (5.81)	18.97 (5.33)
Social motives							
Alcohol	2	2.18	.113	.004	16.49 (4.91)	18.20 (4.74)	18.44 (4.44)
Marijuana	2	0.21	.812	.001	10.57 (5.13)	11.25 (5.29)	12.72 (5.83)
Coping motives							
Alcohol	2	0.97	.381	.002	9.28 (4.06)	10.35 (4.14)	10.01 (3.56)
Marijuana	2	0.29	.750	.001	8.74 (4.73)	9.55 (4.31)	11.25 (5.44)

Note. The Bonferroni adjusted criterion *p*-value for each omnibus ANCOVA was *p*<.0026. Means followed by different letters differ significantly from each other at Bonferroni adjusted *p*<.0167. Models control for age, sex, race/ethnicity, school attended, number of other substances used in the past 3 months, and frequency of both alcohol and marijuana use. Sim NPS refers to simultaneous NPS with alcohol use for alcohol motives and simultaneous NPS with marijuana use for marijuana motives.

Teter et al., 2003), we found that the Non-Sim NPS group also reported greater drinking frequency, quantity, and HED episodes than the No NPS group. The Sim NPS group also reported using marijuana more frequently and spent more hours high in a typical week than the other two groups. Moreover, the Sim NPS group reported experiencing more marijuana-related consequences than the No NPS group, although it did not differ from the Non-Sim NPS group.

Thus, students who use alcohol or marijuana simultaneously with prescription stimulants report a more problematic course of use of that substance than those who do not use prescription stimulants and even than those who use them but do not use them simultaneously with other drugs. This pattern of findings suggests that, overall, students who engage in NPS with other substances on board display a distinct profile of alcohol consumption at risky levels and heavier and more frequent marijuana use that differs from other students who use multiple products, but not at the same time. In contrast, those who use alcohol or marijuana simultaneously with prescription stimulants were no more likely to report negative consequences of use compared to those who did not use simultaneously. This finding suggests some sort of underlying propensity toward experiencing problematic substance use and engaging in poly-substance use (e.g., Donovan & Jessor, 1985; Krueger et al., 2007) rather than something specific to the combination of the two substances on a given occasion.

Our second hypothesis was only partially supported. Though we did not find overall effects for group differences in enhancement motives, as we had hypothesized, the Sim NPS group most often reported using marijuana to increase the effect of another drug, which in a sense is an effect enhancement motive. Within a laboratory setting, Kollins et al. (2015) found that participants in a combined THC with methylphenidate condition reported greater subjective effects than single substance groups, including endorsement of the items "Feel Drug Effect," "Good Effects," and "Take Again." These findings suggest that combining stimulants

with marijuana may enhance their effects. Moreover, the Sim NPS group also reported using marijuana to decrease the effect of another drug, suggesting these students may be more likely to use marijuana to come down from or suppress the effects of stimulants. The fact that the Sim NPS group reported using marijuana to both increase and decrease the effects of other drugs might be explained by differences in species of marijuana. For example, some users distinguish between cannabis indica and cannabis sativa. They perceive that indica makes them feel "sleepy/tired" or "relaxed," whereas sativa makes them feel "alert," "energized," and "motivated" (Sholler et al., 2021). Users report using indica when they want to go to sleep and sativa at a party, suggesting that situational factors may influence motivations. Nonetheless, more laboratory studies are needed to validate user perceptions of differences in species effects. Although the SIM NPS group reported more motives for increasing/decreasing the effects of marijuana, they did not significantly differ from the other groups in motives for increasing/decreasing the effects of alcohol, suggesting that students who engage in simultaneous NPS with alcohol do not differ from other students on these motives.

Interestingly, we did not see any group differences in using marijuana or alcohol to get to sleep. Although some students explicitly state that they use alcohol as a sleep aid (almost 12%; Taylor & Bramoweth, 2010), and although 15% report they have used marijuana as a sleep aid (Goodhines et al., 2019), most students do not use for these reasons. Thus, it may be that overall alcohol and marijuana are not generally motivated by sleep effects but on the few occasions when students use stimulants, they turn to marijuana to induce sleep. Future studies are needed to examine whether timing or order of substances used is related to motivations for use.

Additionally, there were no differences among NPS groups in terms of social motives or coping motives for alcohol or marijuana use. College students more broadly report greater endorsement of social motives, which may be a normative aspect of the college experience and not necessarily associated with a high-risk course of substance use. In contrast, though coping motives more broadly have been associated with problematic patterns of substance use, many studies of college students have found that coping motives are not as frequently endorsed in this population (Cooper et al., 2016). In fact, examination of motive means demonstrates that coping motives were reported at a lower frequency than all other types of motives. Thus, with regard to students engaging in higher risk forms of substance use (e.g., simultaneous NPS use with alcohol or marijuana), motives pertaining to combining NPS with marijuana to enhance or diminish effects might be the ones to target in interventions.

On college campuses, alcohol and other drug prevention efforts are commonly in place for first-year students, student-athletes, fraternity and sorority members, and mandated students, typically emphasizing prevention among potentially high-risk students. Our findings point to a potentially "hidden" high-risk group of students who engage in simultaneous NPS with alcohol or marijuana, possibly to alter the subjective effects experienced by a given substance. One means of potentially identifying a "hidden" group is systematic screening for NPS and even simultaneous use. Screening, brief intervention, and referral to treatment (SBIRT) is recommended by the US Preventive Services Task Force and the National Institute on Alcohol Abuse and Alcoholism's College Alcohol Intervention Matrix (CollegeAIM) as an effective strategy, and screening can routinely take place in campus counseling and health centers. Considering the Sim NPS group reported more frequent marijuana use than the other two groups, and given the research clearly demonstrating negative associations between marijuana use and academic outcomes (Arria et al., 2015), this group of students could be referred to on-campus services that provide support, consultation, and treatment.

Efforts to better understand motives for simultaneous use could inform substance use harm-reduction interventions. In this study, students who engaged in simultaneous NPS with marijuana reported greater motives for using marijuana to both increase and decrease the effects of another substance compared to other students. Although we cannot conclude which substance necessarily comes first, it is possible that students experiencing unwanted or excessive stimulant effects of NPS are seeking an "antidote" by using a substance with depressant effects (e.g., marijuana). Considering the risks associated with drug interactions and other polysubstance-related harms, future research may focus on developing targeted interventions strategies for students expressing such behaviors and motives.

Findings from this study have important implications for screening efforts in health and counseling settings. Simply knowing that a student flags for use of one substance (e.g., NPS) and/or another (e.g., alcohol or marijuana) may not capture the intricacies of polysubstance use and unique risks experienced by that student. Efforts to distinguish concurrent use of substances from simultaneous use of substances, particularly in screening settings, can help to paint a clearer picture of risks a student may be facing.

Based on these findings, future studies could build on efforts to reliably assess simultaneous use of two or more substances and examine how to most meaningfully assess poly-substance use. With years of research questioning the degree to which there is a "gateway" component to marijuana use (e.g., Volkow et al., 2014), future studies could also attempt to elucidate the temporal ordering of poly-substance use. Future studies could examine the degree to which students are aware of drug interaction risks and understand potential harms and "benefits" associated with simultaneous use. Furthermore, the effect sizes in our sample revealed that the magnitude of the differences in substance use is considerably larger than for motives, suggesting that other substance use may better differentiate these groups than an assessment of motives. It is also important to note that the magnitude of the effects for consequences was relatively small compared to the other substance use variables suggesting that even though substance use patterns are what most strongly distinguish the groups, consequences are not as profoundly different. This may imply that alcohol and/or marijuana use alone may be a primary driver of consequences (as use frequency was controlled in the consequence models), although simultaneous use with stimulants may

put individuals at some level of increased risk. Replication of this pattern of results would increase confidence in these findings.

Current study findings should be interpreted in light of several limitations. First, the parent study was not designed for the objective of the current study, so our assessment of NPS evaluated lifetime and past 3-month use as dichotomous and did not evaluate frequency of use or use of a wider range of prescription stimulants beyond Adderall or Ritalin. It also did not take into account individuals with prescriptions who overuse their prescription. Due to the small number of simultaneous users, we considered whether simultaneous use occurred, but not the degree or intensity of simultaneous use. In addition, although we focused on recent (past 3-month) NPS users, we could not assess whether the simultaneous use occurred in the past 3 months. Further, our study was unable to document use of three or more substances simultaneously. Our measure of motives for using alcohol and marijuana to increase or decrease the effects of another substance were not specific to NPS. We cannot infer the substance for which participants endorsed using alcohol or marijuana to enhance or diminish the effects; we could only indicate that those who reported simultaneous NPS with marijuana were more likely to endorse these items. Thus, we hope our study will motivate future work that focuses deliberately on simultaneous use of NPS with other substances. In addition, specific motives for engaging in NPS were not assessed in this study. It is likely that participants engaging in simultaneous NPS may report different motivations for NPS (e.g., recreational; McCabe et al., 2015) than students who engage in NPS without other substances (e.g., academic). This was a sample of past-year alcohol and marijuana users from three college campuses; thus, our findings may not generalize to students at other colleges, non-college students, or other-aged populations. Additionally, students using alcohol and marijuana monthly were oversampled, which may have biased the results.

Despite these limitations, we believe that this study makes an important contribution to the literature by being the first to demonstrate that students who engage in simultaneous NPS with alcohol or marijuana report specific motives for engaging in marijuana use (e.g., increase/decrease the effect of another substance), compared to those who engage in NPS without simultaneously using them with alcohol or marijuana, and students who do not engage in NPS. This study also replicates the finding that students who engage in NPS without alcohol or marijuana on board also report heavier drinking and marijuana use than those who do not engage in NPS (Arria et al., 2013; Kilmer et al., 2021; McCabe et al., 2005, 2006a, 2007; Rabiner et al., 2009b; Teter et al., 2003). Moreover, students who engage in simultaneous use of stimulants with alcohol or marijuana experience greater alcohol- and marijuana-related consequences than those with no stimulant use history (Arria et al., 2013; McCabe et al., 2006b). This study builds on the existing literature indicating that students who engage in NPS, and especially those who engage in NPS with other substances on board, represent a high-risk group of students who are prone to experiencing a more problematic course of substance use.

Contributors

Nicole Fossos-Wong led coordination of authors, conducted data analyses, and wrote portions of the manuscript. Jason Kilmer and Ha-Yoon Lee assisted the first author with manuscript writing. Alexander Sokolovsky provided consultation on data analysis and wrote portions of the manuscript. Helene White and Kristina Jackson wrote portions of the manuscript and were the Principal Investigators of the grant from which the study data was drawn. All authors conducted multiple rounds of edits and revisions prior to submission.

Declaration of interest

The authors declare that they have no conflict of interest. The authors alone are responsible for the content and writing of the article.

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