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The Temporal Association Between Simultaneous Alcohol and Cannabis Use and High-Risk Sexual Behaviors

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THE TEMPORAL ASSOCIATION BETWEEN SIMULTANEOUS ALCOHOL AND CANNABIS USE AND HIGH-RISK SEXUAL BEHAVIORS

by

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ABSTRACT

THE TEMPORAL ASSOCIATION BETWEEN SIMULTANEOUS ALCOHOL AND CANNABIS USE AND HIGH-RISK SEXUAL BEHAVIORS

by

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High-risk sexual behaviors (HRSBs; e.g., having sex without protection against pregnancy or sexually transmitted infections) are a public health problem. HRSBs disproportionally impact college students and are associated with numerous negative outcomes, such as unwanted pregnancies. Alcohol use has been strongly linked to HRSBs in college students, but the research is less clear when investigating the relationship between cannabis use and HRSBs. Additionally, there is a lack of research examining the relationship between simultaneous alcohol and cannabis (i.e., marijuana or SAM) use (i.e., using alcohol and cannabis at the same time so that the effects overlap) and HRSBs in college students. Thus, the current study aimed to examine this relationship temporally utilizing a 30-day daily diary design in alcohol and cannabis using college students. Participants (N = 103) completed brief, daily surveys for 30 consecutive days measuring their SAM use and HRSBs. Moderators, including sex-related SAM expectancies and impulsivity, of this relationship were also investigated. Results indicated no significant associations between SAM use and HRSBs. No significant two-way interactions between sex-related SAM expectancies or positive urgency were found. A significant association between positive urgency and HRSBs was observed, such that as positive urgency decreased, participants had lower odds of engaging in HRSBs. When accounting for negative urgency, SAM use was significantly related to HRSBs, such that not engaging in SAM use decreased the likelihood of

engaging in HRSBs. Further, results suggested evidence for a significant two-way interaction between SAM use and sensation seeking. Specifically, for participants high in sensation seeking, relative to low, the odds of engaging in HRSBs decreased for those participants that did not engage in SAM use, compared to those that did in engage in SAM use. Significant associations between age, such that as age increased, the odds of engaging in HRSBs increased, and sex assigned at birth, such that males were at lower odds of engaging in HRSBs than females, were also observed. Results need additional replication to confirm findings, but may suggest a need to target older, female students, positive urgency, and negative urgency to reduce HRSBs.

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LIST OF ABBREVIATIONS

ACSUS	Alcohol and Cannabis Simultaneous Use Scale
CARE-R	Cognitive Appraisal of Risky Events-Revised
CBD	Cannabidiol
CESD-10	Center for Epidemiologic Studies Depression Scale-10
GEE	Generalized Estimating Equations
HRSB	High-Risk Sexual Behavior
PSWQ	Penn State Worry Questionnaire
QIC	Quasi Likelihood under Independence Model Criterion
SAM	Simultaneous Alcohol and Cannabis (i.e., Marijuana) Use
STI	Sexually Transmitted Infections
SUPPS-P	Short UPPS-P Impulsive Behavior Scale
UWM	University of Wisconsin-Milwaukee

High-risk sexual behaviors (HRSBs), defined for this study (and consistent with prior research; Metrik et al., 2016; Simons et al., 2010) as having sex (oral, anal, or vaginal) without protection against pregnancy or sexually transmitted infections (STIs), having sex after the use of alcohol or drugs, and/or having sex with someone the individual just met or does not know well, are a public health problem. HRSBs are associated with negative outcomes, including STIs and unwanted pregnancies (Cooper, 2002) that disproportionally impact college students and young adults. Individuals between the ages of 15-24 are responsible for acquiring half of all new STIs (Satterwhite et al., 2013) and their treatment costs the US approximately $15.6 billion per year (Owusu-Edusei et al., 2013). Further, nearly 9% of college students report having four or more sexual partners and over half report not using a condom during vaginal intercourse in the past 12 months (American College Health Association, 2017).

Additionally, alcohol and cannabis use rates are highest in college-aged young adults (Substance Use and Mental Health Services Administration [SAMHSA], 2018). Approximately 56% of young adults (18-25 years old) report alcohol use in the past month and 37% report binge drinking (4/5 or more drinks on one occasion for women/men) in the past month, which is higher than any other age group (SAMHSA, 2018). Approximately 22% of young adults report using cannabis in the past month, which is also higher than any other age group (SAMHSA, 2018). Thus, it is not surprising that research has established a relationship between alcohol and cannabis use and HRSBs in college students. Yet, there is a dearth of research examining the relationship between simultaneous alcohol and cannabis (i.e., marijuana or SAM) use (i.e., using both alcohol and cannabis at the same time so that the effects of both drugs overlap) and HRSBs. With the increasing legalization of cannabis and frequency of SAM use in young adults, it is

critical to elucidate the relationship between SAM use and HRSBs to inform future research and intervention.

Alcohol Use and HRSBs

In college students, alcohol-related HRSBs are common. Nearly 50% of college students report using alcohol prior to sexual encounters with a new partner (Testa et al., 2015), 32% engage in alcohol use prior to unprotected vaginal intercourse (Brown & Vanable, 2007), and 65% report not using a condom during sex after drinking (LaBrie & Earlywine, 2000). Retrospective studies found that alcohol use was related to a decreased likelihood to use condoms with a new partner (Scott-Sheldon et al., 2010) and a meta-analysis indicated that for every 0.1mg/mL increase in blood-alcohol levels, intentions to engage in unprotected sex increased by 3% (Rehm et al., 2012). Another review of alcohol use and HRSBs determined that there was a strong relationship between alcohol use and unplanned sexual behaviors (e.g., casual sex with a new partner) and that regular alcohol users reported more sexual partners than nonusers (Cooper, 2002). Daily diary studies have provided additional support for the relationship between alcohol use and HRSBs in college students by demonstrating that alcohol increases the likelihood of sex with a new partner and unprotected sex (Kiene et al., 2009; Testa et al., 2015). Thus, there is a strong link between alcohol use and HRSBs.

Cannabis Use and HRSBs

Research investigating the relationship between cannabis use and HRSBs is mixed and the majority has utilized cross-sectional methodology. For instance, a cross-sectional study investigating adolescent couples found that cannabis reduced the likelihood of discussing sexual risk prior to sexual engagement (Kingree & Betz, 2003). Retrospective interview studies have found that cannabis use was related to not using condoms with a casual partner in young adult

women (Anderson & Stein, 2011) and an increased likelihood of being sexually active in young adults (Metrik et al., 2016). On the other hand, cannabis use was not associated with increased odds of unprotected sex with a casual partner in a study utilizing retrospective interview methods (Metrik et al., 2016). Cannabis use has also been shown to not increase acute risk for intention to engage in HRSBs in a laboratory setting in which participants were administered THC (Skaliski et al., 2017). Thus, research is mixed when investigating the relationship between cannabis use and HRSBs, but there is little research examining this relationship utilizing methods that capture event-level, temporal data.

SAM use and HRSBs

Among people who drink alcohol, cannabis is the most commonly used drug, other than tobacco (Subbaraman & Kerr, 2015). People who use both alcohol and cannabis are two times more likely to use them simultaneously (i.e., at the same time so that the effects of the drugs overlap) rather than concurrently (i.e., using both substances but not necessarily at the same time; Subbaraman & Kerr, 2015). Studies examining cannabis-using college students and young adults have found that almost half report using alcohol simultaneously (Haas et al., 2015; Subbaraman & Kerr, 2015). Further, SAM use increases the risk of negative outcomes above and beyond using either substance alone. These negative outcomes include increased health problems, depressive symptoms, and increased risk of substance use problems in the future (Green et al., 2016; Haas et al., 2015; Midanik et al., 2007; Subbaraman & Kerr, 2015). Further, SAM users are at increased risk for experiencing social consequences (e.g., engaging in fights while under the influence of SAM use), alcohol-related problems (e.g., blackouts), cognitive consequences (e.g., not feeling as sharp mentally due to use), and causing harm to oneself, compared to alcohol-only users (Jackson et al., 2020; Midanik et al., 2007; Subbaraman & Kerr,

2015; Yurasek et al., 2017). Preliminary cross-sectional research has also indicated that SAM users are higher in specific facets of impulsivity (positive urgency and negative urgency) than concurrent alcohol and cannabis users (i.e., people who use alcohol and cannabis but not at the same time) and alcohol-only users (Jackson et al., 2020). Additionally, SAM users reported more sensation seeking behaviors compared to alcohol-only users (Jackson et al., 2020) and all of these facets of impulsivity are known risk factors for HRSBs (e.g., Deckman & DeWall, 2011). Overall, SAM use is a prevalent behavior in college students and young adults and is associated with numerous, detrimental outcomes.

Despite a growing prevalence of SAM use among young adults, few studies have examined the association between SAM use and HRSBs and the current literature has found mixed results. A cross-sectional study examining the prevalence of SAM use and HRSBs in college students found that 36.3% reported engaging in SAM use prior to sexual intercourse at least once in the past 3 months and 34.1% endorsed heavy drinking simultaneously with cannabis use prior to sexual intercourse at least once in the past 3 months (Kolp et al., 2020). One retrospective interview study found that heavy alcohol use and cannabis use interacted to increase the likelihood of unprotected sex with an established partner (Metrik et al., 2016), while another cross-sectional study found that cannabis and blood alcohol concentration levels did not interact to predict HRSBs (Simons et al., 2010). Further, one study utilizing a retrospective interview did not find that SAM use was associated with HRSBs in young adult women (Anderson & Stein, 2011). Overall, few studies have investigated the relationship between SAM use and HRSBs and the existing results are mixed.

Additionally, few studies have examined relationships between substance use and HRSBs using event-level methodology, such as daily diary studies. Previous studies (Metrik et al., 2016;

Simons et al., 2010) have primarily utilized cross-sectional designs when assessing the relationship between alcohol, cannabis, or SAM use and HRSBs. This is problematic for several reasons. First, temporal implications regarding the relationship between variables cannot be determined. Second, when examining SAM use cross-sectionally, it is difficult to determine if the use of alcohol and cannabis occurred at the same time, or near enough so that the effects of the drugs overlapped. In contrast, daily diary methods allow researchers to have a more detailed, accurate description of participants' daily activities, including a more accurate assessment of SAM use and how it may relate to HRSBs. Daily diary studies are appropriate when the goal is to examine relationships between behavior (e.g., SAM use, HRSBs), but are not suitable for temporary states (e.g., mood; Shiffman, 2009). Thus, a daily dairy design is appropriate for the constructs in the proposed study. Daily diary designs also help to reduce recall bias that is inherent with other types of methodology. Further, they help determine whether future, more intensive and expensive studies (e.g., studies using EMA) are warranted by providing key information on frequencies and associations among constructs. Utilizing daily diary methods to examine the temporal relationship between SAM use and HRSBs will help fill the gaps currently existing in the literature and provide important information for future studies on SAM use and HRSBs.

Theoretical Considerations

Alcohol myopia theory is the prominent theory used to explain the relationship between alcohol use and HRSBs (Steele & Josephs, 1990). Alcohol myopia theory states that the disinhibiting effects of alcohol narrows an individual's attentional processing and, therefore, their ability to perceive cues in the environment (Giancola et al., 2010). This narrowing of attention permits highly salient cues to be processed (e.g., sexual arousal) while other, more

distal cues are not recognized (e.g., risk of STIs from unprotected sex) that may have otherwise stopped them (Steele & Josephs, 1990). Thus, alcohol use can lead to riskier decision making and engagement in sexual behavior the individual may not have otherwise engaged in when not drinking. This theory has been supported through a review of alcohol use and HRSBs (Cooper, 2006) and daily diary studies (e.g., Kiene et al., 2009).

There is a lack of existing theory to explain the relationship between cannabis use and HRSBs. The limited existing research suggests that sex-related cannabis expectancies (e.g., feeling closer to a partner after smoking cannabis) may influence the decision to engage in HRSBs, rather than cannabis acutely increasing the risk for HRSBs. For instance, one study found that stronger sex-related cannabis expectancies (i.e., beliefs that cannabis enhances sexual experiences) predicted increased frequency of cannabis use in sexual situations among adolescents involved in the juvenile justice system (Hendershot et al., 2010). Further, the authors found that the relationship between cannabis use and decreased condom usage was moderated by sex-related cannabis expectancies, such that this relationship was stronger if they had high, relative to low, sex-related cannabis expectancies (Hendershot et al., 2010). Another study administered THC to young adult participants prior to engaging in an interactive sexual role-play task to investigate participants' intentions to engage in sexual activity without a condom (Skaliski et al., 2017). Results indicated that the pharmacological effects associated with THC did not impact HRSBs, but sex-related cannabis expectancies did increase a participant's willingness to consider sexual activity with a new partner without a condom (Skaliski et al., 2017). Thus, this preliminary evidence indicates that cannabis use may increase risk for HRSBs only if sex-related cannabis expectancies are high, rather than acutely increasing risk through pharmacological effects, but further research is necessary to confirm and replicate these findings.

No theory currently exists to explain the relationship between SAM use and high-risk behaviors, including HRSBs. It is possible that SAM use may increase the myopic effects associated with alcohol use (e.g., disinhibition; Weafer & Filmore, 2012), as SAM use effects are additive (e.g., the effects of alcohol and cannabis are compounded; Chait & Perry, 1994; Ramaekers et al., 2011) and related to certain disinhibiting effects (e.g., difficulty concentrating, confusion; Lee et al., 2017). These disinhibiting effects may increase an individual's risky decision making and, in turn, their likelihood of engaging in HRSBs above and beyond the effects of either substance alone. It is also possible that the relationship between SAM use and HRSBs may be moderated by sex-related SAM expectancies, such that individuals high in sex-related SAM expectancies have an increased likelihood of engaging in HRSBs under acute effects of SAM use, relative to individuals low in sex-related SAM expectancies, but no research currently exists examining sex-related SAM expectancies. Overall, the literature is lacking in terms of explaining the mechanisms regarding the relationship between SAM use and HRSBs. More research is necessary to further explore this relationship and the associated mechanisms.

Additionally, researchers have theorized that the relationship between alcohol and cannabis use and HRSBs may be influenced by third variables (Bryan et al., 2012; Cooper, 2002). It is possible this is also the case for SAM use and HRSBs, and impulsivity may be one variable that impacts this association. Initial evidence examining the relationship between impulsivity and SAM use has found a relationship between SAM use and certain facets of impulsivity, including sensation seeking, negative urgency, and positive urgency. For instance, a cross-sectional study among young adults examining past-year SAM users found past-year SAM users reported higher levels of sensation seeking compared to alcohol-only users (Linden-Carmichael, Stamates, & Lau-Barraco, 2019). Another cross-sectional study in young adults with

past-year alcohol use found that sensation seeking was the only facet of impulsivity that predicted the likelihood of recent SAM use, as compared to alcohol use only. This same study also developed different profiles of impulsivity types and found that those high in sensation seeking, negative urgency, and positive urgency were most likely to engage in SAM use, compared to those with low or moderate impulsivity (Stamates et al., 2022). Another study in young adults utilizing retrospective interviews discovered that participants high, relative to low, in negative urgency had a positive relationship with same-day grams of cannabis and number of standard drinks consumed (Daros et al., 2022). Studies examining the relationship between facets of impulsivity and HRSBs have found similar relationships. For instance, sensation seeking (craving novel, exciting situations) was related to drug-related HRSBs (e.g., sexual acts with a partner using alcohol; Charnigo et al., 2013). A longitudinal study found that negative urgency (acting rashly after experiencing negative emotion), positive urgency (acting rashly after experiencing positive emotion), and sensation seeking were related to engaging in HRSBs (e.g., sex with a stranger) in college students (Deckman & DeWall, 2011). Thus, it is plausible that these facets of impulsivity (sensation seeking, positive urgency, and negative urgency) may moderate the relationship between SAM use and HRSBs.

Proposed Study

HRSBs are a prevalent public health problem. Research has established a clear relationship between alcohol use and HRSBs, but the relationship between cannabis use and HRSBs is less clear. Further, there are few studies investigating the relationship between SAM use and HRSBs and current results are mixed. To inform future research and intervention aimed at reducing SAM use and HRSBs, research utilizing event-level methodology is needed. Theoretically, the disinhibiting effects of alcohol and cannabis may compound during SAM use

to place an individual at increased risk for HRSBs, and risk may be further increased for individuals high in, relative to low in, sex-related SAM expectancies and impulsivity.

Study Aims

Based on the above research and theory, the following aims were proposed.

Aim 1: Examine the temporal relationship between SAM use and HRSBs.

Hypothesis 1A: SAM use will temporally precede and increase the odds of HRSBs to a greater degree than alcohol or cannabis use alone.

Aim 2: Investigate whether impulsivity (sensation seeking, positive urgency, and negative urgency) and sex-related SAM expectancies moderate the relationship between SAM use and HRSBs.

Hypothesis 2A: The temporal relationship between SAM use and HRSBs will be stronger when impulsivity is high, relative to low.

Hypothesis 2B: The temporal relationship between SAM use and HRSBs will be stronger when sex-related SAM expectancies are high relative to low.

Method

Participants

A sample of 103 college students were recruited for the current study. The inclusion criteria were as follows: (a) must be between the ages of 18 and 25 years old, (b) must have consumed alcohol and cannabis in the past month, (c) must have engaged in sexual activity (defined as oral, anal, or vaginal intercourse) in the past month, and (d) were not currently quarantined (e.g., were not leaving the house for 5-14 days) due to the COVID-19 pandemic. Participants were not eligible for the proposed study if they were in a sexual or romantic relationship with someone under the age of 18. This protected the scientific integrity of the

current study as there are no legal obligations to intervene in sexual relationships occurring with individuals 18 years old or older.

Most participants identified their current gender as a woman ($N = 72$), with 27 participants identifying as men, and 4 participants identifying as genderqueer, non-binary, or androgyne. Twenty-seven participants identified their sex assigned at birth as male, 75 identified their sex assigned at birth as female, and one participant preferred not to answer. The average age of participants was 21.17 ($SD = 1.81$) and most participants (25.2%) were in their fourth year of school, followed by third year (24.3%), second year (19.4%), graduate students (11.7%), first year (10.7%), and fifth year or above (7.8%). Additionally, the majority of students identified as White (75.5%), followed by African American/Black (10.8%), Hispanic, Latino, Latine, or Spanish origin (9.8%), Asian (2%), and American Indian (1%). Most participants (88.2%) did not identify as Hispanic, Latine, or Spanish origin. Further, most participants (68%) were in a current dating relationship. The majority of participants identified as straight or heterosexual (63.1%), followed by bisexual (17.5%), queer (6.8%), pansexual (5.8%), gay (2.9%), another sexual orientation (2.9%), and lesbian (1%).

Procedure

Participants were recruited from a population of undergraduate and graduate students. Recruitment occurred in several ways. First, students enrolled at the University of Wisconsin-Milwaukee (UWM) and partaking in a psychology class were able to view the study via the psychology research pool. In the psychology research pool, participants viewed a brief description of the study online and took a short screening survey on Qualtrics.com to determine eligibility, if they were interested in participating. Second, flyers were posted in buildings both on UWM's campus and in off-campus locations, such as restaurants and vape shops. Third,

flyers were emailed to various student organizations, offices, and departments on college campuses. Finally, participants were recruited using social media platforms, including Facebook and Instagram, through posts including the study flyer. Interested participants were able to take a short Qualtrics.com screening survey to determine eligibility. Participants who met the eligibility criteria, through the screening survey, were contacted and told they have the opportunity to complete an optional research opportunity that will last for 30 consecutive days.

Participants who enrolled in the study completed a baseline session before beginning the daily surveys to gather information regarding impulsivity, sex-related SAM expectancies, prior HRSBs, alcohol use, cannabis use, and SAM use. The baseline session took approximately 2 hours to complete and occurred virtually. Following baseline, participants were emailed a link to the daily questionnaires for 30 consecutive days. Participants received this email at 6:00am through Qualtrics.com. Completion of the surveys took approximately 5 minutes and participants answered the questions regarding their experiences the previous day (i.e., since the time they woke up until the time they went to sleep), consistent with prior daily diary research (Shorey et al., 2014). To increase compliance with the daily surveys, participants who had not completed their survey by 5pm received a reminder email. Further, participants who missed one day of daily surveys received a phone call or text reminder. At the end of the 30 days of daily questionnaires, participants completed one final, brief session virtually in which they were debriefed and received compensation.

Participants received 2 hours of course credit, if enrolled in an eligible psychology course at UWM, or $30 for completing the initial baseline survey. They then received $1 for each completed daily survey and a $5 bonus if they complete at least 80% of the daily surveys, a $10 bonus if they completed at least 85% of the surveys, and a $15 bonus if they completed at least

90% of the surveys. Similar compensation strategies have been used in prior daily diary studies with good compliance rates across 30 days (i.e., 90%; Testa et al., 2018).

Baseline Measures

Demographics questionnaire. A demographic questionnaire was utilized to collect information on sex assigned at birth, gender identity, age, year in college, race, ethnicity, sexual orientation, and current relationship status.

Alcohol use. The AUDIT was used to measure alcohol use. The AUDIT is a 10-item self-report measure designed to examine past 12-month alcohol use (e.g., "How often did you have a drink containing alcohol during the past 12 months?") and alcohol-related problems (e.g., "How often during the past 12 months did you find that you were not able to stop drinking once you had started?"; Saunders et al., 1993). Scores on the AUDIT can range from 0 to 40, with higher scores indicating increased alcohol use and alcohol-related problems. The AUDIT is a reliable and valid measure for use in college students (Lundin et al., 2015), has good internal consistency (Cronbach's alpha in the .80's; Reinert & Allen, 2002), and high sensitivity and specificity values when utilizing a cutoff score of 9 to identify potentially hazardous drinking (de Meneses-Gaya et al., 2009). The internal consistency in the current sample was good ($\alpha = 0.84$).

Cannabis use. The CUDIT-R was utilized to measure cannabis use. The CUDIT-R is an 8-item self-report measure that examines past 12-month cannabis use (e.g., "How many hours were you "stoned" on a typical day when you had been using cannabis in the past 12 months?"), cannabis problems (e.g., "How often during the past 12 months did you fail to do what was normally expected from you because of using cannabis?"), cannabis dependence (e.g., "How often during the past 12 months did you find that you were not able to stop using cannabis once you had started?"), and psychological components of cannabis use (e.g., "How often in the past

12 months have you had a problem with your memory or concentration after using cannabis?"; Adamson et al., 2010). Scores on the CUDIT-R can range from 0 to 32, with higher scores indicating increased cannabis use and cannabis-related problems. The CUDIT-R has good internal consistency (α = .91), discriminant validity by differentiating cannabis abuse and cannabis dependence, and has established a preliminary cutoff score of 13 to identify people with a probable cannabis use disorder (Adamson et al., 2010). The internal consistency in the current sample was good (α = .80).

SAM use. The Alcohol and Cannabis Simultaneous Use Scale (ACSUS) was used to measure SAM use. The ACSUS is a 9-item self-report measure that examines past 12-month SAM use (e.g., "How often did you use both alcohol and marijuana on the same occasion during the past 12 months, so that the effects of alcohol and marijuana overlapped?") and SAM-related problems (e.g., "How often during the past 12 months did you fail to do what was normally expected from you because of using both marijuana and alcohol on the same occasion, so that the effects of alcohol and cannabis overlapped?"; Kolp et al., 2023). The ACSUS was modeled off the AUDIT (Saunders et al., 1993), CUDIT-R (Adamson et al., 2010), and the Daily Sessions, Frequency, Age of Onset, and Quantity of Cannabis Use Inventory (DFAQ-CU Inventory; Cuttler & Spradlin, 2017) and was developed by utilizing exploratory and confirmatory factor analyses from two independent samples of college students. Scores on the ACSUS can range from 0 to 36, with higher scores indicating increased SAM use and SAM-use related problems. The internal consistency of the ACSUS is good (α = .70; Kolp et al., 2023). The internal consistency in the current sample was good (α = .77).

Other drug use. The DUDIT was utilized to measure drugs not already measured in the AUDIT, CUDIT-R, and SAM-USE Scale including amphetamines, cocaine, opiates, and

barbiturates (Stuart et al., 2003). The DUDIT is an 14-item self-report measure that investigates past 12-month drug use ("About how often do you use cocaine [for example, intranasal, IV, crack, freebase, "speedball," or other]?") and drug-related problems ("How often during the past 12 months have you found that you were not able to stop using drugs once you had started?"; Stuart et al., 2003). Scores on the DUDIT can range from 0 to 56, with higher scores indicating increased drug use and drug-related problems. The DUDIT has high internal consistency (α = .90; Stuart et al., 2003). The internal consistency in the current sample was good (α = .68).

HRSBs. The Cognitive Appraisal of Risky Events-Revised (CARE-R) questionnaire (Fromme et al., 1999; Katz et al., 2000) measured past HRSBs. The CARE-R is an 11-item self-report measure that asks participants about past 6-month frequency of HRSBs (e.g., "had sex without protection against sexually transmitted diseases"; Fromme et al., 1999; Katz et al., 2000). At the beginning of the measure, the CARE-R asks participants to indicate the number of weeks they would need to date someone to consider them a regular partner. The CARE-R then asks participants to answer each question for both a regular partner, using the definition they indicated at the beginning, and for a partner that they just met or do not know well (e.g., "sex without protection against pregnancy with: (a) a regular partner and/or (b) someone I just met and do not know well"; Fromme et al., 1999; Katz et al., 2000). The CARE-R has been utilized in college student samples and has good internal consistency (Cronbach's alpha in the .80's; Katz et al., 2000). The internal consistency in the current sample was good for both HRSBs with a regular partner (α = .78) and a new partner (α = .83).

Impulsivity. The Short UPPS-P Impulsive Behavior Scale (SUPPS-P) is a 20-item self-report scale that assesses the five facets of impulsivity (Cyders et al., 2014). For the present study, three facets of impulsivity will be utilized, including negative urgency (.g., "When I feel

bad, I often do things I later regret in order to make myself feel better now"), positive urgency (e.g., "When I am very happy, I can't seem to stop myself from doing things that can have bad consequences"), and sensation seeking (e.g., "I generally seek new and exciting experiences and sensations"; Cyders et al., 2014). Participants are instructed to rate how much they agree or disagree with each statement, with higher scores on each scale indicating increased impulsivity (Cyders et al., 2014). The SUPPS-P has adequate reliability, inter-correlations comparable to the UPPS-P, factor structure consistent with the UPPS-P, and correlations with external measures (e.g., AUDIT) similar to the UPPS-P (Cyders et al., 2014). The internal consistencies in the current sample were as follows: negative urgency (α = .73), positive urgency (α = .72), and sensation seeking (α = .62).

Sex-related SAM expectancies. Sex-related SAM expectancies were assessed using a 13-item self-report measure developed from previous research that examined sex-related alcohol expectancies (Dermen & Cooper, 1994) and sex-related cannabis expectancies (Hendershot et al., 2010). The items are designed to measure sexual enhancement (e.g., "After using alcohol and cannabis at the same time, I feel closer to a sexual partner"), sexual risk ("After using alcohol and cannabis at the same time, I am less likely to use birth control"), and disinhibition ("After using alcohol and cannabis at the same time, I am more likely to have sex on a first date"; Dermen & Cooper, 1994). Participants will be asked to rate how SAM use impacts their sexual feelings and behaviors on a scale of 1 (strongly disagree) to 5 (strongly agree), with higher scores indicating stronger expectancies. Prior research has demonstrated high internal consistencies (α = .82-.91; Hendershot et al., 2010). The internal consistency in the current sample was good (α = .87).

COVID-19. Items from the Epidemic-Pandemic Impacts Inventory (Grasso et al., 2020) were modified to determine whether behaviors relevant to the current study had been impacted by the COVID-19 pandemic (e.g., decrease in sexual activity, increase in cannabis use), with the following prompt: "Since the coronavirus disease pandemic began, what has changed for you or your family?" Participants could indicate whether their behavior had changed or not. Responses will be utilized to inform ways in which participants' experiences and behaviors may have changed during the COVID-19 pandemic.

Depressive symptoms. The Center for Epidemiologic Studies Depression Scale-10 (CESD-10) was utilized to measure depression symptoms over the past week (e.g., "I could not 'get going'"; Andresen et al., 1994). This measure is a 10-item scale, with response options ranging from rarely or none of the time (less than 1 day) to all the time (5-7 days). A cut-off score of 10 was determined to identify depressive symptoms (Andresen et al., 1994). The CES-D is a widely used depression measure and has been established for use in adolescents and adults (Baron et al., 2017). The CESD-10 has demonstrated good test-retest reliability and is correlated with other aspects related to depression (e.g., negatively correlated with positive affect; Andersen et al., 1994). The internal consistency in the current sample was good ($\alpha = .83$).

Worry. The Penn State Worry Questionnaire (PSWQ) is a 16-item measure assessing trait worry (e.g., "my worries overwhelm me"; Meyer et al., 1990). The PSWQ has shown to discriminate between those who meet criteria for generalized anxiety disorder versus post-traumatic stress disorder and has shown good test-retest reliability. The PSWQ was developed for use in college students (Meyer et al., 1990). Scores can range from 16-80, with higher scores indicating increases in worry. The internal consistency in the current sample was good ($\alpha = .79$).

Daily Diary Measures

During the 30-day daily diary portion, participants reported on the behaviors below. I collected detailed information on the timing of behaviors (alcohol use, cannabis use, HRSBs) to establish within-day sequencing of behaviors for temporal data analyses, consistent with prior daily diary research (Testa et al., 2015). Participants answered the questions regarding their experiences the previous day (i.e., since the time they woke up until the time they went to sleep).

Alcohol Use. Participants were asked if they used alcohol the previous day. If they did use alcohol, participants were asked to report the number of standard drinks they consumed, what time they started and stopped drinking, and level of perceived intoxication, consistent with prior studies (Shorey et al., 2014; Testa et al., 2015).

Cannabis Use. Participants were asked if they used cannabis the previous day. If they did use cannabis, they were asked to report what time they started and stopped using cannabis, level of perceived intoxication, THC content of the cannabis product, how much cannabis they used (all products converted into grams), and how they used cannabis (e.g., smoked flower, smoked concentrates, edibles), consistent with prior research (Shorey et al., 2014; Testa et al., 2018).

Other Drug Use. Participants were asked if they used any non-prescription drugs (e.g., cocaine, heroin, Adderall not prescribed to them) other than alcohol or cannabis the previous day. If participants did use non-prescription drugs, they were asked to identify which non-prescription drugs they used and what time they started and stopped using non-prescription drugs.

SAM Use. SAM use was determined by the reported overlap of alcohol and cannabis use. If alcohol and cannabis were used within 3 hours of each other it was deemed SAM use, consistent with prior research (Lipperman-Kreda et al., 2017).

Sexual Experiences. Participants were asked whether they engaged in sexual activity (touched a partner underneath their clothing or with no clothing on; had oral, vaginal, and/or anal intercourse) the prior day. If they did engage in sexual activity, they were asked about HRSBs and the time in which the activity occurred.

HRSBs. Participants were asked whether they engaged in a variety of HRSBs with the following question: "Please indicate if you had sex without protection against pregnancy, had sex without protection against sexually transmitted infections, or had sex without a condom" from the CARE-R. Participants were also asked to indicate (a) what time these behaviors occurred the previous day, (b) with whom the behavior occurred with (a regular partner, someone they just met and don't know well, a former sexual partner, acquaintance, friend, other), (c) if they have engaged in sexual activity with this person before, and (d) whether their sexual partner used any substances prior to or while engaging in sexual behavior with them.

COVID-19. Participants were asked whether they were quarantined (i.e., did not leave their house) due to COVID-19, whether they tested positive for COVID-19, and to rate their worry about COVID-19 on a scale of 1 (not at all) to 5 (extreme worry).

Sample Size Determination

There is no established effect size in the literature for the temporal relationship between SAM use and HRSBs. Thus, small-to-medium effects sizes were expected in the proposed study based on previous research investigating the temporal relationship between alcohol use and HRSBs (Rehm et al., 2012) and theory indicating that SAM use may compound the effects of alcohol and cannabis on HRSBs (Chait & Perry, 1994). Additionally, previous research utilizing simulation studies for two-level models suggest 100 observations in Level-2 and between 3 to 30 observations in Level-1 for small-to-medium effect sizes, with a minimum power of 0.80, is

appropriate (Arend & Schafer, 2019; Maas & Hox, 2005). A sample size of 103 participants provided the ideal amount of observations for Level-2 and Level-1, as each participant has up to 30 Level-1 observations. Further, previous 30-day daily diary studies have utilized a sample size of 100 participants to investigate HRSBs with significant results (e.g., Wray & Monti, 2020) and other studies have found significant results with as few as 50 participants (e.g., Grov et al., 2010). Therefore, a sample size of 103 is adequate for the current study.

Data Analytic Plan

First, baseline and daily measures (e.g., HRSBs, SAM use, other substance use) were utilized to report descriptive statistics about the sample. Next, compliance rates were calculated by determining the number of missed daily assessments to the number of total assessments. Despite some missing data from noncompliance and attrition, data from all participants were used in analyses because the chosen generalized linear model analyses used all available data and estimated missing data from Bayesian rules, even from participants with as few as 3 days. Data was analyzed using generalized estimating equations (GEE) in SPSS, as HRSB was a dichotomous variable (e.g., engaged in HRSBs or not) and GEE allows for time-varying independent and dependent variables (Liang & Zeger, 1986). Covariate variables were characterized as numerical variables (e.g., sensation seeking) and factor variables were characterized as categorical variables (e.g., sex assigned at birth). The daily data were transformed into a long dataset format and broken down into 24-hour increments, such that each participant had 720 hours of data over the 30-day daily period to account for hourly time effects within study variables.

Analyses examined alcohol, cannabis, and SAM use by coding each substance use variable to be dichotomous, such that 0 signified no substance use and 1 indicated substance use.

SAM use was considered if both alcohol and cannabis were used within 3 hours prior to HRSBs, as supported by prior literature (Lipperman-Kreda et al., 2017). Thus, lagged variables were created to account for SAM use at each hour, up to three hours, including concurrent SAM use (alcohol and cannabis use within the same hour), alcohol and cannabis within one hour of each other, alcohol and cannabis use within two hours of each other, and alcohol and cannabis use within three hours of each other. To address concerns with Type 1 error, the false discovery rate method was used to correct for multiple comparisons, which is more powerful in detecting true effects than other methods (e.g., Bonferroni; Gelman & Yajima, 2012). Further, daily analyses were limited to participants that reported engaging in at least one act of sexual behavior over the course of the survey period to ensure the possibility of HRSBs occurring (N = 87 participants; 1,007 hours of survey days).

Further, time was included within the model to account for results varying across different time periods, given increased use of substance use in young adults on weekends versus weekdays (Braitman, Lau-Barraco, & Stamates, 2021; Patrick, Yeomans-Maldonado, & Griffin, 2016). To determine which time period best fit the current models, two different time periods were tested, informed by both the existing literature and the current data. First, a weekend variable was created in which Thursday through Saturday was coded as the weekend (coded as 1) and the remaining days were coded as weekdays (coded as 0). Second, another weekend variable was created, but Friday through Sunday was coded as the weekend (coded as 1) and the remaining days were coded as weekdays (coded as 0). Previous studies examining young adult drinking and cannabis use have considered weekends to include Thursday through Saturday due to increased substance use on those days (e.g., Braitman, Lau-Barraco, & Stamates, 2021; Patrick, Yeomans-Maldonado, & Griffin, 2016). The Friday through Sunday weekend variable

was created due to sexual behavior occurring most frequently on these days in the current sample.

Aim 1 was to examine whether SAM use temporally preceded and increased the odds of HRSBs. This was achieved through regressing HRSBs onto the categorical SAM use variable, while accounting for alcohol use, cannabis use, age, sex assigned at birth (male coded as 0; female coded as 1), and time. Aim 2 was to investigate whether impulsivity (sensation seeking, positive urgency, and negative urgency) and sex-related SAM expectancies moderate the relationship between SAM use and HRSBs. This was accomplished the same way as Aim 1 in that HRSBs was regressed onto the dichotomously coded, categorical substance use variables, with a facet of impulsivity entered as a numerical variable, and interactions between SAM use and each of the three facets of impulsivity included. This procedure was repeated with sex-related SAM expectancies entered as a numerical variable. Additionally, I explored whether findings varied across sex assigned at birth. To do so, HRSBs was regressed onto the dichotomously coded, categorical substance use variables and sex assigned at birth was entered as a categorical variable, with an interaction between SAM use and sex included. Finally, I explored whether COVID-19 worry, quarantine from COVID-19, or testing positive for COVID-19 impacted HRSBs. To do so, HRSBs was regressed onto the dichotomously coded, categorical substance use variables and two models were run, with the COVID variables entered as either a categorical (quarantine from COVID-19) or a numerical variable (COVID-19 worry). A model was not run for the testing positive for COVID-19 variable, due to low endorsement ($N = 11$ days endorsed).

Results

Descriptive Statistics

The overall daily compliance rate was 90% (a total of 2,775 surveys completed). Cannabis was used a total of 3,772 hours on 54% of survey days, with 88% of the sample using cannabis at least once over the 30 days. On cannabis use days, participants reporting using an average of 0.85 grams (range 0.125-23; *SD* = 1.45), with participants reporting they were not sure how much cannabis they used on 199 survey days. Further, on cannabis use days, participants reported using cannabis with an average of 19.42% THC content (range 0%-30%). Regarding subjective intoxication on cannabis use days, participants reported on average feeling "moderately high" (M = 2.57; *SD* = 0.58) on a scale of 1 (not at all high) to 5 (extremely high). Alcohol was used a total of 1,943 hours on 64% of survey days, with 89% of the sample drinking alcohol at least once over the 30 days. On drinking days, participants reported drinking an average of 3.5 drinks (range 1-16; SD = 2.59). For subjective intoxication on drinking days, participants reported on average feeling "slightly drunk" (M = 2.16; *SD* = 1.11) on a scale of 1 (not at all drunk) to 5 (extremely drunk). At baseline, 86% of participants reported engaging in SAM use over the past year. Within the daily surveys, concurrent SAM use (i.e., using cannabis and alcohol in the same hour) occurred a total of 391 hours on 7% of survey days, with 56% of the sample engaging in concurrent SAM use at least once over the 30 days. Expanding SAM use to include cannabis and alcohol use within 1 hour of each other revealed a total of 600 hours, SAM use within 2 hours of each substance indicated a total of 1,070 hours, and SAM use within 3 hours of each substance determined a total of 1,474 hours of use. Non-prescribed drugs, excluding alcohol and cannabis, were used a total of 104 hours across survey days.

A total of 616 acts of vaginal intercourse occurred on 25% of survey days, with 75% of the sample engaging in at least one act of vaginal intercourse. A total of 67 acts of anal intercourse occurred on 12% of survey days, with 14% of the sample engaging in at least one act. A total of 451 acts of oral intercourse occurred on 21% of survey days, with 75% of the sample engaging in at least one act. A total of 836 acts of touching someone (e.g., a partner, acquaintance) underneath their clothing or with no clothing occurred on 27% of survey days, with 82% of the sample engaging in at least one act. Overall, 85% ($N = 87$) of the sample reported engaging in at least one act of sexual behavior over the 30 days. Additionally, a total of 482 acts of engaging in sex without protection against pregnancy, STIs, or sex without a condom occurred on 21% of survey days, with 63% of the sample engaging in at least one act of this behavior across the 30 days. Participants reported engaging in sexual behavior with regular partners on the majority of days in which sexual behavior occurred (90%). Finally, participants reported their sexual partners used substances, with cannabis as the most common substance reported, prior to engaging in sexual behavior on 9.4% ($N = 290$) of survey days.

Among participants that identified as women, 86% reported using cannabis, 89% reported drinking alcohol, and 47% reported engaging in concurrent SAM use at least once across the 30 days. Further, among participants that identified as women, 79% reported touching someone (e.g., a partner, acquaintance) underneath their clothing or with no clothing, 72% reported engaging in oral intercourse, 75% reported engaging in vaginal intercourse, 10% reported engaging in anal intercourse, and 64% reported engaging in sex without protection against pregnancy, STIs, or sex without a condom on at least once across the 30 days. Among participants that identified as men, 93% reported using cannabis, 93% reported drinking alcohol, and 85% reported engaging in concurrent SAM use at least once across the 30 days. Further,

among participants that identified as men, 93% reported touching someone (e.g., a partner, acquaintance) underneath their clothing or with no clothing, 85% reported engaging in oral intercourse, 81% reported engaging in vaginal intercourse, 26% reported engaging in anal intercourse, and 63% reported engaging in sex without protection against pregnancy, STIs, or sex without a condom on at least once across the 30 days. Among participants that identified as genderqueer, non-binary, or androgyne, 100% reported using cannabis, 75% reported drinking alcohol, and 25% reported engaging in concurrent SAM use at least once across the 30 days. Further, among participants that identified as genderqueer, non-binary, or androgyne, 75% reported touching someone (e.g., a partner, acquaintance) underneath their clothing or with no clothing, 75% reported engaging in oral intercourse, 50% reported engaging in vaginal intercourse, 25% reported engaging in anal intercourse, and 50% reported engaging in sex without protection against pregnancy, STIs, or sex without a condom on at least once across the 30 days.

Bivariate correlations (Table 1) conducted with baseline variables revealed alcohol use and problems was significantly and positively related to cannabis and SAM use. Alcohol use and problems was negatively and significantly related to negative urgency, positive urgency, and sensation seeking. Cannabis use and problems was positively and significantly related to SAM use, sex-related SAM expectancies, and HRSBs with a new partner. Cannabis use and problems was negatively and significantly related to positive urgency and sensation seeking. SAM use was significantly and positively related to sex-related SAM expectancies and HRSBs with a new partner. SAM was significantly and negatively related to negative urgency and positive urgency. HRSBs with a new partner was significantly and negatively related to sensation seeking. Negative urgency was significantly and positively related to positive urgency. Depressive

symptoms were significantly and negatively related to positive urgency and negative urgency. Depressive symptoms were significantly and positively related to worry. Worry was significantly and positively related to sensation seeking. Worry was significantly and negatively related to negative urgency. Depressive symptoms and worry were not significantly related to either substance use or HRSBs at baseline and, thus, were not included in subsequent analyses.

In terms of the ways participants perceived the COVID-19 pandemic as impacting their behavior, 40% reported an increase in drinking and 64% reported an increase in cannabis use. Further, 25% of participants reported they had limited physical closeness with a partner or spouse due to concerns of infection and 65% reported limited physical closeness with friends due to concerns of infection. Additionally, 35% of participants reported an increase in sexual activity and 20% reported a decrease in sexual activity during the pandemic. Within the daily surveys, there were 59 days in which a participant reported being quarantined (i.e., not leaving their house due to COVID) and 11 days in which a participant reported testing positive for COVID-19. On average within the daily surveys, participants reported feeling "slightly worried" (M = 1.46; SD = 0.78) about contracting COVID-19 on a scale of 1 (not at all) to 5 (extreme worry).

Generalized Linear Model Analyses

To determine which weekend variable best fit the current models, the Quasi Likelihood under Independence Model Criterion (QIC) statistic was examined, with the lowest number indicating better model fit (Wedderburn, 1974). Ultimately, the Friday through Sunday time variable best fit the current models (QIC = 1362.45) as compared to the Thursday through Saturday weekend variable (QIC = 1364.01) and was used in the present models.

Aim 1 results examining the temporal relationship between SAM use and HRSBs, while accounting for daily alcohol use, daily cannabis use, age, sex assigned at birth, and weekend

versus weekday (weekend coded as Friday through Sunday), indicated no significant main effects of SAM use on HRSBs (Table 2). Significant main effects were found for both age and sex assigned at birth throughout all models, regardless of SAM use timeframe (i.e., concurrent use, 1 hour lagged use, 2 hour lagged use, and 3 hour lagged use). Specifically, for each one-year increase in age, the odds of engaging in HRSBs was increased by 1.24 times (95% CI: 1.06-1.45). For sex assigned at birth, results indicated that the odds of a male engaging in HRSBs was 0.44 times lower than the odds of a female engaging in HRSBs (95% CI: 0.21-0.93). In the model that included the one-hour lagged substance use variables, there was also a significant interaction between SAM use and time, suggesting that not engaging in SAM use on weekdays was associated with reduced odds of engaging in HRSBs (OR = 0.11; 95% CI: 0.04-0.52). There was no significant association between SAM use and HRSBs on weekends.

Further, I examined the main effects model with both COVID-19 items (quarantine due to COVID-19 and worry about COVID-19) entered into a model. Neither of these COVID-19 items were significantly related to HRSBs and, thus, were not entered into subsequent models.

Aim 2 examined whether impulsivity (sensation seeking, negative urgency, and positive urgency) and sex-related SAM expectancies moderated the relationship between SAM use and HRSBs. Results indicated no significant two-way interactions or main effects for sex-related SAM expectancies. Positive urgency also did not moderate this relationship but did have a significant main effect on HRSBs within the two-hour lagged substance use model, such that as positive urgency decreased, the odds of HRSBs decreased (OR = 0.34; 95% CI: 0.12-0.96; Table 3). Results also did not indicate a significant two-way interaction between SAM use and negative urgency in any of the models. Within the concurrent and 3-hour lagged substance use models, there was a significant main effect of SAM use on HRBS, such that participants that did not

engage in SAM use had decreased odds of engaging in HRSBs (Concurrent model: OR = 0.24; 95% CI: 0.06-1.00; $p = 0.05$; 3-hour model: OR = 0.48; 95% CI: 0.23-1.00), as compared to participants that did engage in SAM use. Finally, sensation seeking had a significant two-way interaction with SAM use in the two hour and three-hour lagged substance use models, providing a preliminary signal of a moderation effect (Table 4). Decomposition of this interaction suggested that among those high in sensation seeking (2-hour model: OR = 207.73; 95% CI: 1.11-17.43; 3-hour model: OR = 221.02; 95% CI: 1.11-17.43), relative to low (2-hour model: OR = 3.52; 95% CI: 1.11-17.43; 3-hour model: OR = 3.21; 95% CI: 1.11-17.43), the odds of engaging in HRSBs decreased for those participants that did not engage in SAM use, compared to those that did engage in SAM use. These moderation results should be interpreted with caution, as the present models were likely underpowered to detect reliable effects.

The final exploratory aim examined whether results varied across sex assigned at birth. Results indicated no significant two-way interactions between sex assigned at birth and SAM use in predicting HRSBs.

Finally, the Benjamini-Hochberg procedure was utilized to correct for the false discovery rate with multiple comparisons (Thissen, Steinberg, & Kuang, 2002). After using this procedure, the significant main effect of SAM use ($p = 0.05$) within the concurrent substance use negative model was no longer significant. All other significant main effects and interaction effects remained significant.

Discussion

Previous studies have established a robust relationship between alcohol use and HRSBs (e.g., Testa et al., 2015), with the relationship between both cannabis use and SAM use and HRSBs less clear (e.g., Anderson & Stein, 2011; Metrik et al., 2016). The existing studies

examining SAM use and HRSBs have largely used retrospective methods, indicating a need to further investigate this relationship using temporal methodology. Therefore, the present study examined the temporal relationship between SAM use and HRSBs in college students utilizing a 30-day daily diary design. Results indicated no significant association between SAM use and HRSBs after accounting for alcohol use, cannabis use, age, sex assigned at birth, and time.

Existing research examining SAM use and HRSBs is limited and demonstrated mixed findings. One potential reason the present study did not find a significant main effect between these behaviors may be that SAM use increases intoxication effects of both alcohol and cannabis use beyond capacity to engage in HRSBs. For instance, several studies have suggested that SAM use is associated with increased intoxication effects, such as blacking out and vomiting, above the effects of either alcohol or cannabis use alone (e.g., Jackson et al., 2020; Sokolovsky et al., 2020). Additionally, a previous study has indicated alcohol can increase the absorption rate of THC in cannabis, potentially increasing intoxication effects (Lukas & Orozco, 2001). Therefore, this increased intoxication, and associated negative outcomes, may reduce the likelihood or capability of engaging in HRSBs. It is also possible there is no temporal relationship between SAM use and HRSBs. Initial evidence investigating whether cannabis attenuates drinking has suggested cannabidiol (CBD), a compound found in cannabis, was associated with fewer drinks, fewer drinking days, and fewer alcohol and cannabis co-use days (Karoly et al., 2021). Overall, additional research examining the nuances of the temporal relationship between SAM use and HRSBs is warranted, given the prevalence of these behaviors in college students and young adults.

Results did not indicate a significant association or interaction between sex-related SAM expectancies and HRSBs. The present study was the first study to examine sex-related SAM

expectancies within the relationship between SAM use and HRSBs. These findings do not align with other studies conducted with cannabis-using adolescents and young adults that found sex-related cannabis expectancies were associated with increased HRSBs (Skaliski et al., 2017; Hendershot et al., 2010). Additionally, a recent study conducted in college students found that increases in positive cannabis sociability expectancies (i.e., sexual and social facilitation by cannabis use) was associated with a 25% increase in past-month SAM use frequency. These results also found that as positive alcohol sociability expectancies (i.e., sexual and social facilitation by alcohol use) increased, past-month SAM use frequency decreased by 44% (Berry et al., 2023). Thus, these results may indicate a need to investigate sex-related cannabis expectancies separately from sex-related SAM expectancies. Overall, additional research is needed to examine substance-related sex expectancies and their impact on HRSBs.

Results also indicated significant associations between certain facets of impulsivity and HRSBs. The present study found that as positive urgency decreased, the odds for HRSBs decreased. This finding is consistent with prior work, including longitudinal investigations, linking positive urgency to increased HRSBs in college students (Deckman & DeWall, 2011; Zapolski, Cyders, & Smith, 2009). This association is hypothesized to be due to college students often engaging in parties or celebrations when positive mood is high and in which substance use and opportunity to engage in HRSBs is increased.

Further, there were no significant moderation effects with negative urgency. Within the negative urgency model for three-hour lagged substance use, there was a significant main effect of SAM use, such that not engaging in SAM use decreased odds of engaging in HRSBs. These results indicate that accounting for negative urgency may play an important role within the relationship between SAM use and HRSBs. This is consistent with previous findings. For

instance, one study found SAM users endorsed increased levels of negative urgency compared to concurrent cannabis and alcohol users and alcohol-only users (Jackson et al., 2020) and negative urgency has been linked to HRSBs (Deckman & DeWall, 2011). These results may suggest a need to target negative urgency as one potential way to reduce the risk of engaging in HRSBs. Interventions aimed at increasing emotional regulation may be one such way to help regulate the impacts of increased negative urgency on HRSBs.

Further, the present study found preliminary evidence that sensation seeking moderated the relationship between SAM use and HRSBs, such that for the participants high in sensation seeking, relative to low, the odds of engaging in HRSBs decreased for those participants that did not engage in SAM use, compared to those that did in engage in SAM use. These results must be interpreted with caution, as the present study was likely underpowered to detect these findings, as evidenced by the large odds ratios and confidence intervals for these findings. These findings are also contradictory from previous studies that linked sensation seeking to SAM use (Linden-Carmichael, Stamates, & Lau-Barraco, 2019). One potential explanation for the present study's findings may be that participants do not find the increased intoxication effects (e.g., vomiting, blacking out) of SAM use reinforcing or exciting and choose not to engage in SAM use, even if they are higher in baseline levels of sensation seeking. Overall, additional studies with increased power are needed to replicate these findings.

Further, results indicated significant main effects between age and HRSBs, such that as age increased, odds of engaging in HRSBs increased. Previous studies have demonstrated related findings, in that sexual behavior increases as years in college increase and condom usage decreases as years in college increases (Siegel, Klein, & Roghmann, 1999). The odds of engaging in HRSBs may increase as age increases due to having additional opportunities to

engage in sexual behavior. This may be potentially due to older students being more likely to live in off-campus housing with less oversight than dorm housing or living with parents.

Further, the present study found that men were at lower odds of engaging in HRSBs compared to women. This is contradictory to previous findings indicating that men engage in increased HRSBs, such as decreased use of contraceptives (Mahalik, Levi-Minzi, & Walker, 2007; Poppen, 1995). Given participants reported engaging in sexual behavior with a regular partner on the majority of days in which sexual behavior occurred, it is possible women felt more comfortable reducing use of contraceptives or protection against STIs with a regular partner. For instance, previous research in young adults reported qualitative data indicating participants were less likely to utilize condoms when engaging in sexual behavior with a regular partner (Kenyon et al., 2010). Further research is necessary to replicate these findings and further investigate reasons women may have for engaging in HRSBs.

The present study had a few limitations. First, the majority of participants Identified as white, heterosexual, and as women. Thus, results may not be generalizable to samples identifying outside of these demographics. Additionally, the present study took place in a state in which cannabis is not legalized for recreational use. It is possible different results may be found in places in which cannabis is legal for recreational uses and, thus, more readily accessible. The present study also utilized a 3-hour timeframe for determining SAM use, based on the limited available literature. Another recent study has suggested no differences in subjective intoxication effects or substance use consequences when conceptualizing SAM use as any time between 1 minute to 4 hours (Sokolovsky et al., 2020), but there remains limited research indicating how to define time between cannabis and alcohol use to determine SAM. Further, the present study utilized one item to assess HRSBs in the daily surveys. Future studies should aim to separate

these HRSBs to determine if they are differentially impacted by SAM use. Finally, the present study took place after the start of the COVID-19 pandemic. Although participants did not report a significant amount of worry due to COVID-19 on the daily surveys, it is possible a change in sexual behavior occurred at the cohort level due to the pandemic, but additional research is needed to further examine this.

There are several directions for future research regarding the relationship between SAM use and HRSBs. First, future studies should continue to focus on recruiting more diverse samples, such as including more participants that identify as men and young adults that are not college students to determine if these results generalize to other samples. Second, there is limited research detailing the time period in which SAM use can occur to be considered simultaneous use. Given the constant evolution of cannabis available for use and cannabis research, future studies need to continue investigating this timeframe to increase accuracy of a SAM use definition. Further, it is likely that the amount and potency of alcohol and cannabis consumed may impact the outcomes associated with SAM use, but additional research is needed to determine this. Third, despite the wealth of literature examining substance related-HRSBs, the literature lacks a concise and definitive definition of HRSBs in the context of substance use (Chawla and Sarkar, 2019). Additional research focused on defining HRSBs within the context of substance use is necessary to provide increased specificity around potential interventions aimed at reducing substance related-HRSBs. Finally, the present study utilized retrospective recall of behaviors that occurred the previous day. Given the time-sensitive nature of SAM use and its potential impact on HRSBs, future studies utilizing ecological momentary assessment may be helpful for further elucidation of this relationship.

Overall, the present study was one of the first to examine the temporal relationship between SAM use and HRSBs in college students. These findings extend knowledge around these constructs in college students, a population that is at increased risk for engaging in both SAM use and HRSBs. Results did not demonstrate a temporal relationship between SAM use and HRSBs, suggesting SAM use may not precede and predict this behavior, but additional research is needed to replicate these findings. Further, these results suggest a potential need to target older college students and women with interventions aimed at reducing HRSBs. Preliminary results examining the impacts of facets of impulsivity on this relationship suggested that positive urgency and negative urgency may be an important future construct to target to reduce HRSBs, and sensation seeking may exert an attenuating effect on SAM use and HRSBs, potentially due to the negative effects associated with SAM use. It is important to note these results investigating impulsivity must be interpreted with caution and require additional studies to replicate these results. Future studies investigating these relationships may benefit from utilizing ecological momentary assessment methodology to further investigate the temporal relationship between these behaviors.

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Appendices

Table 1. *Bivariate Correlations Between Baseline Variables.*

	1	2	3	4	5	6	7	8	9	10	11
1. Alcohol Use	-----	0.27**	0.69**	0.14	0.32**	0.13	-0.27**	-0.49**	-0.35**	0.12	-0.04
2. Cannabis Use		-----	0.42**	0.40**	0.24*	-0.02	-0.16	-0.30**	-0.24*	0.08	-0.05
3. SAM use			-----	0.29**	0.36**	0.20	-0.25*	-0.55**	-0.18	0.17	-0.03
4. Sex-Related SAM Expectancies				-----	0.26*	0.04	-0.12	-0.31**	-0.10	0.02	-0.16
5. HRSB with a new partner					-----	-0.20	-0.11	-0.20	-0.22*	0.19	-0.12
6. HRSB with a regular partner						-----	0.01	-0.11	-0.04	-0.01	0.02
7. Negative Urgency							-----	0.42**	-0.01	-0.36**	-0.34**
8. Positive Urgency								-----	0.13	-0.33**	-0.05
9. Sensation Seeking									-----	0.06	0.37**
10. Depressive Symptoms										-----	0.58**
11. Worry											-----
Mean	8.14	11.89	6.00	36.77	2.65	19.52	2.60	3.02	2.40	12.09	57.66
SD	5.46	6.22	4.98	10.85	3.86	9.72	0.70	0.65	0.70	5.95	14.80

* $p < .05$ ** $p < .001$

Table 2. *Generalized Estimating Equation Analyses Predicting HRSBs.*

Concurrent Hour Substance Use		HRSBs	95% Confidence Interval	
Independent Variables	*B (SE)*	*Odds Ratio*	*Lower*	*Upper*
SAM Use	-0.40 (0.68)	0.67	0.18	2.54
Alcohol Use	0.14 (0.30)	1.15	0.65	2.06
Cannabis Use	0.02 (0.23)	1.02	0.65	1.62
Age	**0.21 (0.08)****	**1.24**	**1.06**	**1.45**
Sex Assigned at Birth	**-0.82 (0.38)***	**0.44**	**0.21**	**0.93**
Time (Weekend vs. Weekday)	1.95 (1.18)	7.06	0.70	71.32
SAM Use x Time	-1.95 (1.18)	0.10	0.01	1.42
One-Hour Lagged Substance Use		HRSBs	95% Confidence Interval	
Independent Variables	*B (SE)*	*Odds Ratio*	*Lower*	*Upper*
SAM Use	-0.25 (0.56)	0.78	0.26	2.33
Alcohol Use	-0.27 (0.28)	0.77	0.44	1.33
Cannabis Use	-0.02 (0.23)	0.98	0.63	1.54
Age	**0.21 (0.08)***	**1.23**	**1.05**	**1.44**
Sex Assigned at Birth	**-0.82 (0.37)***	**0.44**	**0.22**	**0.91**
Time (Weekend vs Weekday)	**1.99 (0.61)****	**7.29**	**2.20**	**24.15**
SAM Use x Time	**-1.95 (0.66)****	**0.11**	**0.04**	**0.52**
Two-Hour Lagged Substance Use		HRSBs	95% Confidence Interval	
Independent Variables	*B (SE)*	*Odds Ratio*	*Lower*	*Upper*
SAM Use	-0.36 (0.39)	0.70	0.33	1.51
Alcohol Use	-0.08 (0.33)	0.92	0.49	1.74
Cannabis Use	0.13 (0.28)	1.14	0.66	1.97
Age	**0.20 (0.08)***	**1.22**	**1.04**	**1.43**
Sex Assigned at Birth	**-0.82 (0.38)***	**0.44**	**0.21**	**0.93**
Time (Weekend vs Weekday)	0.68 (0.54)	1.98	0.69	5.69
SAM Use x Time	-0.62 (0.58)	0.37	0.17	1.68
Three-Hour Lagged Substance Use		HRSBs	95% Confidence Interval	
Independent Variables	*B (SE)*	*Odds Ratio*	*Lower*	*Upper*
SAM Use	-0.52 (0.38)	0.59	0.28	1.24
Alcohol Use	0.25 (0.37)	1.28	0.62	2.65
Cannabis Use	0.17 (0.29)	1.18	0.67	2.07
Age	**0.20 (0.08)***	**1.22**	**1.04**	**1.43**
Sex Assigned at Birth	**-0.83 (0.38)***	**0.44**	**0.21**	**0.93**

Time (Weekend vs Weekday)	0.58 (0.49)	1.79	0.69	4.65
SAM Use x Time	-0.52 (0.54)	0.35	0.20	1.72

Note: Bolded text represents significant effects. Sex assigned at birth was coded as 0 = male; 1 = female. Time was coded as weekday = 0; weekend (Friday-Sunday) = 1.
*$p < 0.05$, **$p < 0.01$

Table 3. *Generalized Estimating Equation Analyses Predicting HRSBs with Positive and Negative Urgency Moderations.*

Positive Urgency				
Two-Hour Lagged Substance Use		HRSBs		
			95% Confidence Interval	
Independent Variables	*B (SE)*	*Odds Ratio*	*Lower*	*Upper*
SAM Use	-0.50 (0.37)	0.61	0.30	1.25
Alcohol Use	-0.19 (0.33)	0.83	0.43	1.58
Cannabis Use	0.08 (0.27)	1.08	0.64	1.83
Age	**0.21 (0.08)****	**1.23**	**1.06**	**1.44**
Sex Assigned at Birth	**-0.85 (0.39)***	**0.43**	**0.20**	**0.92**
Time (Weekend vs Weekday)	0.11 (0.18)	1.11	0.79	1.58
Positive Urgency	**-1.06 (0.52)***	**0.35**	**0.13**	**0.96**
SAM Use x Positive Urgency	0.87 (0.48)	2.01	0.93	6.14
Negative Urgency				
Three-Hour Substance Use		HRSBs		
			95% Confidence Interval	
Independent Variables	*B (SE)*	*Odds Ratio*	*Lower*	*Upper*
SAM Use	**-0.74 (0.37)***	**0.48**	**0.23**	**1.00**
Alcohol Use	0.22 (0.35)	1.25	0.63	2.45
Cannabis Use	0.15 (0.29)	1.16	0.66	2.05
Age	**0.22 (0.08)****	**1.24**	**1.06**	**1.44**
Sex Assigned at Birth	**-0.86 (0.40)***	**0.43**	**0.19**	**0.99**
Time (Weekend vs Weekday)	0.09 (0.18)	1.10	0.77	1.56
Negative Urgency	-0.03 (0.68)	0.97	0.26	3.64
SAM Use x Negative Urgency	-0.20 (0.63)	0.82	0.24	2.81

Note: Bolded text represents significant effects. Sex assigned at birth was coded as 0 = male; 1 = female. Time was coded as weekday = 0; weekend (Friday-Sunday) = 1.
*$p < 0.05$, **$p < 0.01$

Table 4. *Generalized Estimating Equation Analyses Predicting HRSBs with Sensation Seeking Moderation.*

Two-Hour Lagged Substance Use		HRSBs		
			95% Confidence Interval	
Independent Variables	*B (SE)*	*Odds Ratio*	*Lower*	*Upper*
SAM Use	-0.23 (0.39)	0.80	0.37	1.71
Alcohol Use	0.07 (0.31)	1.07	0.59	1.96
Cannabis Use	0.21 (0.27)	1.23	0.73	2.09
Age	**0.23 (0.09)***	**1.26**	**1.06**	**1.49**
Sex Assigned at Birth	**-0.98 (0.44)***	**0.38**	**0.16**	**0.89**
Time (Weekend vs Weekday)	0.09 (0.18)	1.09	0.77	1.56
Sensation Seeking	**-1.72 (0.74)***	**0.18**	**0.04**	**0.77**
SAM Use x Sensation Seeking	**1.48 (0.70)***	**207.73**	**1.11**	**17.43**
Three-Hour Lagged Substance Use		HRSBs		
			95% Confidence Interval	
Independent Variables	*B (SE)*	*Odds Ratio*	*Lower*	*Upper*
SAM Use	-0.37 (0.38)	0.69	0.33	1.44
Alcohol Use	0.39 (0.34)	1.48	0.76	2.88
Cannabis Use	0.23 (0.28)	1.26	0.73	2.18
Age	**0.23 (0.09)****	**1.26**	**1.06**	**1.50**
Sex Assigned at Birth	**-0.99 (0.44)***	**0.37**	**0.16**	**0.87**
Time (Weekend vs Weekday)	0.08 (0.18)	1.08	0.75	1.56
Sensation Seeking	**-1.77 (0.65)****	**0.17**	**0.05**	**0.60**
SAM Use x Sensation Seeking	**1.54 (0.62)***	**221.02**	**1.39**	**15.60**

Note: Bolded text represents significant effects. Sex assigned at birth was coded as 0 = male; 1 = female. Time was coded as weekday = 0; weekend (Friday-Sunday) = 1.
*$p < 0.05$, **$p < 0.01$