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The role of chronotype, circadian misalignment, and tiredness in the substance use behaviors of gay and bisexual men

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Abstract

Although the potential of alcohol and drugs to detrimentally affect sleep has been established, the potential of tiredness to in turn influence substance use has received less attention. We contend that tiredness increases risk for substance use because tiredness impairs self-regulation and heightens the utility of substances to combat tiredness, albeit temporarily—and that these links are especially important because decision-making regarding use often occurs late at night when people are tired. Accordingly, we investigated chronotype, circadian misalignment, and perceived tiredness as risk factors in substance use among gay and bisexual men (GBM). We analyzed two online survey datasets—one of 3,696 GBM and one of 1,113 GBM—asking participants about their time for most frequently using alcohol or club/party drugs, their chronotype, whether they use substances to stay awake, and use severity. Alcohol use and club/party drug use most often occurred from 9pm onwards (for 51.3% and 75.1% of men, respectively), especially among younger men and evening types. Further, many men with a morning chronotype reported most often using alcohol (33.2%) and drugs (64.7%) from 9pm onwards, implicating circadian misalignment. Additionally, feeling tired was a motivator of alcohol use and drug use (for 53.1% and 26.9% of men, respectively), especially among younger men. Finally, those endorsing this motivation had greater use severity. These findings highlight the importance of chronotype, circadian misalignment, and tiredness in substance use, especially among younger men. We therefore recommend including substance use among the behaviors adversely affected by tiredness from circadian misalignment and inadequate/overdue sleep.

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Keywords

sleep; alcohol; drugs; circadian preference; synchrony effect; men who have sex with men (MSM)

Introduction

People's levels of cognitive and emotional functioning—and thus, their ability and motivation to successfully self-regulate—have been shown to fluctuate over the course of the waking day, often declining later at night (Schmidt, Collette, Cajochen, & Peigneux, 2007). Indeed, impairments in some cognitive functions emerge after being awake for only 14 hours (e.g., monitoring and awareness; Zhou et al., 2012), which roughly equates to 9pm if the individual has been awake since 7am. On average, most people tend to experience decreasing alertness from approximately 6pm onwards (Åkerstedt, Folkard, & Portin, 2004) and increasing tiredness after 12 hours of being awake (Sagaspe et al., 2006). Further, being awake for 17 hours (i.e., midnight, if awake since 7am) causes lowered performance in psychomotor vigilance equivalent to that of 2–3 standard drinks (Dawson & Reid, 1997). Moreover, these dips or troughs in capacities required for self-regulation are expected to occur even sooner at night for those with a morning chronotype or "early birds," compared to evening types or "night owls" (Kerkhof, 1998)—and also for people with a cumulative sleep debt from consecutive nights of insufficient sleep (Dinges et al., 1997; Roehrs et al., 2003). Each of these findings from the sleep science literature is concerning given what we know from the substance use literature about *when* people tend to most often drink alcohol and/or use club/party drugs: at night-time, and especially Friday and Saturday nights (see Shiffman, 2009 for review). However, these two literatures are not often considered together.

There is also evidence suggesting that self-regulation in other behaviors is more difficult at night—for example, people attempting to quit smoking or to adhere to dieting most commonly lapse at night (Fillo et al., 2016; Forman et al., 2017; McKee, Ntoumanis, & Taylor, 2014). Sleep deprivation has also been linked with increased risk-taking (see Womack, Hook, Reyna, & Ramos, 2013, for a review), the increased tendency to select the easier, less demanding task in complex situations (Engle-Friedman et al., 2003), and greater delay-discounting (Reynolds & Schiffbauer, 2004). That both tiredness and substance use are likely to occur at night is further compounded by the finding that cravings for alcohol occur most often at night (Piasecki et al., 2011). Each of these findings has implications for the tired individual when choosing between an easy, immediate pleasure (say, the fourth drink with friends) and a more complex, delayed alternative (say, postponing gratification and defending one's choice of water). That the time for making substance use decisions frequently coincides with the time-of-day when individuals are tired or "not in their circadian prime" for exercising self-regulation (depicted in Figure 1), is described by "circadian misalignment" which refers to the mismatch between an individual's internal circadian preference and the external demands of social schedules or daily life (Baron & Reid, 2014; Curtis, Burkley, & Burkley, 2014; Wittmann et al., 2006). Yet tiredness and circadian misalignment are rarely counted among the factors that amplify risk in substance use.

Although there are numerous studies on the detrimental effects of alcohol and drugs on sleep quality (see Angarita et al., 2016; Brower, Aldrich, & Hall, 1998, for reviews) and on links between sleep disturbance and relapse outcomes (Brooks et al., 2016), research has yet to adequately explore the possibility of a bidirectional relationship between tiredness and drinking (Roehrs & Roth, 2001; Hasler, Smith, Cousins, & Bootzin, 2012). One exception is a recent daily diary study which showed that shorter sleep on a given night predicts greater alcohol use the following day (Fucito et al., 2017). Another study tested a model linking sleep problems to substance use through impaired emotion regulation in adolescents (Edwards, Reeves, & Fishbein, 2015). More generally, sleep health has also gained recognition in recent models of health behavior (Barber, 2014; Hagger, 2014). Relatedly, chronotype research has observed that evening types report greater rates of substance use (e.g., Adan, 1994; Hasler, Soehner, & Clark, 2014; Urbán, Magyaródi, & Rigó, 2011), and this may be partly because, compared to morning types, evening types have more energy for effortful behaviors at night and greater exposure to opportunities for use. However, this overlooks the fact that many morning types may still be making their substance use decisions at night, when they may be tired.

A number of studies have looked at tiredness as a risk factor in adults' alcohol use, generally finding that those with poorer sleep quality or shorter sleep length report greater substance use (e.g., Chaput et al., 2012) or stronger motives of drinking to cope (Digdon & Landry, 2013). Further, a recent study found that daily sleep quality influences craving for alcohol and drugs via its impact on reduced positive affect (Lydon-Staley et al., 2016). Another study of heavy-drinking college students tested a model in which poorer sleep quality partially mediated the association between poor mental health and drinking (Kenney et al., 2013). Furthermore, two recent studies have observed links between poor sleep quality and drug use among gay and bisexual men (GBM; Downing et al., 2016; Duncan et al., 2016). However, more research on tiredness and substance use is needed—especially among GBM who, as a group, face disparities in substance use (Kerridge et al., 2017) and in adverse outcomes of sexual risk-taking which has been linked with use (Feinstein & Newcomb, 2017), namely HIV (CDC, 2016). Emerging evidence also suggests that GBM and other sexual and gender minority groups tend to experience poorer sleep relative to heterosexuals (e.g., Chen & Shiu, 2017; Galinsky et al., 2018; Patterson, Tate, Sumontha, & Xu, 2018), and thus the study of the effects of tiredness on health behaviors among this population appears especially relevant.

Accordingly, we contend that time of day and tiredness are important factors to consider in substance use behavior for two reasons: (1) that many people may be making substance use decisions later than their optimal time of cognitive and emotional functioning, implicating circadian misalignment, such that their tiredness may situationally impair their capacity to self-regulate (Millar, 2017); and (2), that tiredness itself may motivate individuals to use substances to lift their falling energy levels.

The use of alcohol mixed with energy drinks (Grandner et al., 2014) or of stimulant drugs in the battle against feeling tired makes intuitive sense, and is especially common among gay and bisexual men (Wells et al., 2013). However, there is also evidence that alcohol alone (without energy drinks) may also temporarily lift energy due to its more immediate

stimulatory effects, which are perhaps less acknowledged than its more delayed sedative effects (Hendler et al., 2013). Indeed, these two kinds of effects of alcohol are described by the Biphasic Alcohol Effects Scale (Martin et al., 1993), which assesses seven subjective states associated with alcohol's stimulatory effects (e.g., feeling energized, excited, up) and seven associated with its sedative effects (e.g., feeling down, heavy-headed, sluggish). That these stimulatory effects of alcohol may motivate the tired individual is reflected in colloquial terms such as wanting a "pick-me-up" or a "livener." Although enhancement motives were counted among drinking motives (Cooper, Russell, Skinner, & Windle, 1992), research has yet to adequately consider whether tiredness motivates alcohol use, independent of energy drinks.

In sum, time of substance use, concomitant tiredness, the role of circadian misalignment, and tiredness as a motivator of substance use are underappreciated factors in substance use behavior. Accordingly, we aimed to gather preliminary data on these factors by drawing on two different datasets, both in relation to GBM in the U.S.—although it is anticipated that similar dynamics may be at work in other populations. We hypothesized that the majority of GBM would report nighttime (here, 9pm or later) as the time when they most frequently use substances [Hypothesis 1]. We also hypothesized that, although reporting this later time for substance use would be more common among those with a later chronotype, there would be a substantial proportion of morning types who report this later time for most frequent use, potentially implicating circadian misalignment [Hypothesis 2]. Finally, we hypothesized that a substantial proportion of men would endorse the motivation of using substances to help stay awake when tired [Hypothesis 3]. No hypotheses were advanced for whether endorsement of this motivation would vary by chronotype, as both morning and evening types may use substances to stay awake but at different times of night. We also aimed to consider age in these associations because younger age is associated with greater eveningness preference (Randler, 2016; Roenneberg et al., 2007), later times for drinking (Dawson, 1996), and less sensitivity to the sedative effects of alcohol (Spear, 2000). Given the exploratory nature of these analyses, we also tested for potentially relevant demographic differences in these distributions.

Method

STUDY 1 (for Hypotheses 1 and 2)

Participants and procedure—Survey data were drawn between May 2016 and March 2017 from a study of GBM recruited from online sources, in-person at various New York clinics, and in an existing longitudinal study. However, the questions for Hypotheses 1 and 2 were only asked of the 3,696 GBM recruited from the four online sources from across the U.S.: a hook-up website, a hook-up app, porn sites, and Facebook. To be eligible, participants had to report being at least 18, residing in the U.S., being cisgender male, and having had sex with a man in the past five years.

Upon receiving a unique link, participants completed the Qualtrics-hosted survey. Participants were not directly compensated as they were being screened for a paid study, but were entered to win a raffle ($20 Amazon gift card drawn for every 50 participants). All procedures were approved by CUNY's Institutional Review Board.

Measures

Demographics.: Participants were asked a range of questions regarding age, race and ethnicity, sexual orientation, HIV-status, education level, and relationship status.

Chronotype.: Participants rated their chronotype preference on a single item taken from the Horne and Östberg Morningness-Eveningness Questionnaire (Horne & Östberg, 1975). The original 19-item scale was shortened by Adan and Almirall (MEQ-R; 1991) to a five-item scale, in which the single item used here displayed the strongest psychometric properties of the five items, having the highest correlation with the total score of the overall shortened scale ($r = 0.89$; Adan & Almirall, 1991). It has also been used as a sole-item indicator of chronotype in other studies (e.g., Hersh et al., 2015; Turco et al., 2015). The item reads: "Many people describe themselves as a 'morning person' (aka. 'morning type' or 'an early bird'), while many others describe themselves as an 'evening person' (aka. 'night person' or 'a night owl'). Which do you consider yourself to be?". The response options from the original scale were: 1 (*definitely a "morning person"*), 2 (*rather more of a "morning person" than an "evening person"*), 3 (*rather more of an "evening person" than a "morning person"*), and 4 (*definitely an "evening person"*). We inserted an additional option of "neither morning or evening type," as in a previous study (Ramin et al., 2013). These responses were coded as morning types (collapsing 1 and 2), intermediate types, and evening types (collapsing 3 and 4).

Time of most frequent substance use.: Participants indicated the time of day when they most often used alcohol or club/party drugs in recent months. The items were: "During the last 3 months, when have you most often consumed alcohol?" and separately, "… club/party drugs (e.g., cocaine/crack, ecstasy/MDMA, ketamine, crystal meth, GHB, recreational prescription stimulants)?". The response options included: 1 (*mostly in the morning after waking up*), 2 (*mostly in the afternoon*), 3 (*mostly in the evening, 5pm to 9pm*), 4 (*mostly later at night, 9pm or later*), or 5 (*not applicable to me—I haven't consumed this in the last 3 months*).

Analytic Plan for Hypotheses 1 and 2—The following analyses, conducted in SPSS Version 24, were run only for those reporting use of alcohol ($n = 2,814$) and use of club/party drugs ($n = 449$). The times of peak use (whether day, evening 5–9pm, or night from 9pm onwards) of alcohol and club/party drugs, separately, were analyzed at the bivariate level by chi-square tests of independence run according to chronotype grouping (morning type, intermediate type, and evening type). Given the exploratory nature of the study, we also explored comparisons by demographic factors: race and ethnicity, sexual identity, relationship status, HIV status, education, recruitment source, and, in a one-way ANOVA, age. Finally, binary logistic regressions predicted the odds of the later time (9pm onwards, compared to day/evening combined) of alcohol and club/party drug use separately. Chronotype (referent = morning type) was entered in the second step of each model, after adjusting for the covariates that were significant at the bivariate level: age, race and ethnicity (referent = White), recruitment source (referent = hookup/porn sites), relationship status (referent = partnered), and education (referent = less than college degree).

STUDY 2 (for Hypothesis 3)

Participants and procedure—Survey data were drawn from the 24-month assessment of the *One Thousand Strong* project, a longitudinal study following a national cohort of HIV-negative GBM for three years across the U.S. (see Grov et al., 2016). Participants had been identified via Community Marketing and Insight's (CMI) panel of over 22,000 GBM throughout the U.S., and were eligible if they were: at least 18; cisgender male; gay or bisexual; HIV-negative; able to complete at-home self-administered testing for HIV/STIs; had sex with a man in the past five years; had an address to receive mail, not a P.O. Box; and had not moved more than twice in the past six months. Of the 1,071 men who joined the study at baseline, 985 (92.0%) completed the 24-month assessment. For the third year of the study, an additional 128 GBM of color were recruited, receiving this survey as their first assessment. This brought the full sample at the 24 month mark to 1,113 GBM. Participants completed the online Qualtrics survey via a unique link and were compensated with a $25 Amazon gift card. All protocols were approved by the Hunter College Institutional Review Board.

Measures

Demographics.: Participants were asked a range of questions regarding age, race and ethnicity, relationship status, sexual orientation, education, and annual income.

Chronotype.: Chronotype was measured using the five-item MEQ-R (Adan & Almirall, 1991). The items ask participants about the time of day for their "feeling best" rhythm, their preference for when to wake up, their level of tiredness upon waking, and their time of feeling tired in the evening, and also includes the item described in Study 1. Utilizing scoring recommendations in Adan and Almirall, participants were coded into three chronotype categories: morning types, intermediate types, and evening types.

Using substances to stay awake.: Participants responded to three substance use items, given the following sentence stem: "If you are out socializing at night and are becoming tired, do you…". Displaying only for those who reported past-year alcohol use, participants indicated whether they "…drink alcohol to help stay awake for longer" and whether they "…drink alcohol mixed with energy drinks (e.g., Red Bull, coke, coffee, etc.) to help stay awake for longer." Displaying only for those with past-year use of cocaine/crack, crystal methamphetamine, GHB, ecstasy, and prescription stimulants (recreational), participants indicated use of "…drugs to help stay awake for longer." Responses ranged from 0 (*Never*), 1 (*Sometimes*), 2 (*Quite often*), to 3 (*Very often*).

Substance use severity.: Men reporting alcohol use in the past three months completed the 3-item Alcohol Use Disorders Identification Test–Consumption (AUDIT-C; Bush et al., 1998). Scores ranged from 0–12 (α = .63), with higher scores indicating greater use. Men reporting drug use in the past three months completed the Drug Abuse Screening Test (DAST-10; Skinner, 1982)—scores ranged from 0–9 (α =.73), with higher scores indicating greater problems from drug use.

Analytic Plan for Hypothesis 3—The following analyses were run only for those who reported use of alcohol (n = 927) and, separately, for those who reported use of club/party drugs (n = 401). The motivation for use of alcohol and club/party drugs to stay awake, were each analyzed at the bivariate level by chi-square tests of independence run according to chronotype grouping (morning type, intermediate type, and evening type). Additionally, we explored comparisons by demographic factors: race and ethnicity, sexual identity, relationship status, income, education, and, in an independent-samples t-test, age. Differences in use severity scores between those endorsing the motivation (vs. those who did not) were tested using Poisson regressions, adjusting for age and chronotype. In binary logistic regressions predicting the odds of reporting the motivation (again, separately for alcohol and drugs), chronotype (referent = morning type) was entered in the second step of the model, after adjusting for the covariates that were significant at the bivariate level: age, race and ethnicity (referent = White and Black), relationship status (referent = partnered), education (referent = less than college degree), and income (referent = less than $50,000).

Results

As displayed in Table 1, the sample of 2,814 alcohol-using men utilized for Hypotheses 1 and 2 in relation to alcohol had a mean age of 37.7 (SD = 13.3), was mostly White (62.8%), HIV-negative (83.5%), gay (82.3%), and single (62.4%). On average, evening types (56.8%) were younger (M = 35.4, SD = 12.3) than morning types (M = 42.5, SD = 13.9; 28.2%) and intermediate types (M = 37.4, SD = 13.7; 15.0%), $F(2, 2811) = 79.27$, $p < 0.001$.

The majority (51.3%) of these 2,814 alcohol-using men reported that their time of most frequent drinking was from 9pm onwards, followed by evening or 5–9pm (46.2%). Only 2.5% reported drinking most often during the day. Bivariate comparisons showed that intermediate types (50.9%) and evening types (60.4%) were more likely than morning types to report this later time for most frequent drinking (9pm onwards). However, almost one-third (33.2%) of morning types did report this 9pm-or-later time. Further, bivariate comparisons showed that reporting this 9pm-or-later time was more common among younger men, men of color, single men, those with less education, and those who were recruited from the hookup app or Facebook. Table 2 displays the multivariable results, where each of these differences remained significant except for education.

Of the 449 men who reported recent club/party drug use, the majority (75.1%) reported most frequent use occurring from 9pm onwards, followed by evening or 5–9pm (15.8%). Only 9.1% reported peak drug use occurring during the day. Bivariate comparisons showed that intermediate types (79.7%) and evening types (76.9%) were more likely than morning types to report this later time for most frequent drinking (9pm onwards). However, almost two-thirds (64.7%) of morning types did report this 9pm-or-later time. Further, bivariate comparisons showed that reporting the later time of 9pm onwards was more common among gay men (vs. bisexual), while daytime use was endorsed by more partnered than single men. Men endorsing peak use between 5–9pm were, on average, older than those endorsing daytime or later-than-9pm use. In multivariable analyses displayed in Table 2, after adjusting for covariates, only chronotype significantly predicted the time of peak club/party drug use,.

The demographic characteristics of the sample utilized for Hypothesis 3 are displayed in Table 3. Excluding the 186 men with no recent alcohol use, the 927 men with recent alcohol use had a mean age of 40.8 (SD = 13.5), and were mostly White (61.5%). On average, evening types (28.5%) were younger (M = 36.7, SD = 12.3) than morning types (M = 49.0, SD = 13.0; 20.9%) and intermediate types (M = 40.7, SD = 13.2; 50.6%), $F(2, 1110) = 63.7$, $p < 0.001$. The majority (53.1%) of the 927 men reported using alcohol to help stay awake—218 (23.5%) indicated use of both alcohol and alcohol mixed with energy drinks to do so, while 153 (16.5%) reported alcohol only and not energy drinks, and 121 (13.1%) reported drinking alcohol with energy drinks but not alcohol alone. Combining these, almost one-third of morning types (32.0%) endorsed this motivation—however, bivariate comparisons showed that intermediate types (41.2%) and evening types (43.9%) were more likely to do so. Comparisons showed that men endorsing this motivation were, on average, younger and were more likely to be Latino or Multiracial/Other. In Model 1 in Table 4, younger age, being Latino or Multiracial/Other, and higher income were positively associated with endorsing this motivation, while chronotype was not. Additionally, men endorsing this motivation for alcohol use also had higher AUDIT scores than men not endorsing this motivation, adjusting for age and chronotype—Exp(B) = 1.21, 95%-CI: 1.15, 1.27, $p < 0.001$.

Overall, 26.9% of the 401 men with recent club/party drug use reported having used drugs to help stay awake. Almost one-fifth of morning types (19.4%) endorsed this motivation, while 25.5% of intermediate types and 33.6% of evening types did so. Demographic comparisons showed that men endorsing this motivation were, on average, younger. In Model 2 in Table 4, younger age and being White or Black were positively associated with endorsing this motivation, while chronotype was not. DAST items were completed by only 119 men who reported recent use—and on average, the 83 of these men who endorsed this motivation for drug use had higher DAST scores than those who did not, adjusting for age and chronotype —Exp(B) = 1.67, 95%-CI: 1.26, 2.22, $p < 0.001$.

Discussion

Our findings highlight the relevance of time-of-day and tiredness in understanding substance use behaviors, here in relation to GBM who remain at elevated risk of problematic substance use and adverse outcomes related to substance use (namely, HIV), and who also tend to experience comparatively poor sleep quality compared to heterosexuals (Chen & Shiu, 2017; Galinsky et al., 2018; Patterson et al., 2018). Our findings provide support for Hypothesis 1, that alcohol and club/party drug use can both be considered as primarily nighttime activities for the vast majority of the GBM we surveyed. Indeed, very few men reported that drinking (2.5% of men) and club/party drug use (9.1% of men) most frequently occurred during the day. Identifying nighttime as the most likely time for substance use accords with the findings of Shiffman's (2009) review. Further, multivariable analyses showed that both younger age and a later chronotype were associated with increased odds of reporting the later-than-9pm time for drinking, while only chronotype was associated with the later time for club/party drug use. This may be due to any number of lifestyle factors among younger GBM such as employment (e.g., working later shifts) or timing preferences for social activities and norms

amongst friends, and concurs with Dawson's (1996) study which showed that younger adults more commonly report later times of drinking.

In support of Hypothesis 2, times of most frequent alcohol and club/party drug use differed according to chronotype, even when adjusting for age differences between the three chronotype groups. While morning types were more likely to report earlier times for drinking and drug use, a still-substantial number of morning types reported drinking (33.2%) and drug use (64.7%) most often from 9pm onwards. This is important because, by this time of night, it can be expected that the typical morning person would be feeling tired or at least "not in their prime" (see Schmidt et al., 2007). This suggests that many men are not at their optimal level of cognitive and emotional functioning when choosing whether to drink or use drugs, and how to manage their rate of use. Furthermore, the later it gets, the more tired they are expected to become and additionally, the more intoxicated they are likely to be from previous use. The role of circadian misalignment in substance use therefore warrants further investigation.

Our findings also support Hypothesis 3. A majority of alcohol-using GBM (53.1%) reported sometimes using alcohol (whether with or without energy drinks) to help them stay awake if they are out at night and are feeling tired, while 26.9% of drug-using GBM endorsed the same motivation for drug use. In other words, tiredness is a factor that can situationally motivate substance use in a substantial proportion of GBM. Further analyses showed that younger age was associated with increased odds of reporting this motivation for both alcohol and drug use, which is concerning given that rates of problem drinking and drug use are also more pronounced among younger GBM compared to their heterosexual counterparts (Marshal et al., 2008). Finally, use severity scores (AUDIT and DAST) were higher for those endorsing this motivation for use of alcohol and drugs to stay awake.

Previous studies on the use of energy drinks mixed with alcohol have suggested that energy drinks are frequently used to counter the sedative effects of alcohol and to lift energy (Snipes & Benotsch, 2013; Wells et al., 2013). Our findings extend this by showing that a substantial proportion of GBM reported drinking alcohol *without* energy drinks to help them stay awake longer, which resonates with the work of Hendler et al. (2013) regarding the stimulatory effects of alcohol alone. We contend that the experience of being tired and the wish to stay awake longer combine to constitute a motivation for many GBM that increases their substance use, and therefore that this motivation should be counted amongst motives for use (alongside enhancement motives; Cooper et al., 1992). This work extends the focus of existing models of substance use behavior which rely on stable, person-level, cognitive variables (e.g., beliefs, knowledge, personality traits), by also acknowledging the fluctuating influence of physiological processes such as tiredness and circadian rhythms.

We propose that sleep health interventions to increase one's awareness of the effects of tiredness and to address poor sleep—which was recently named a "public health epidemic" (CDC, 2015), and especially so for sexual and gender minority individuals (Chen & Shiu, 2017; Galinsky et al., 2018; Patterson et al., 2018)—could help to prepare GBM with greater alertness, cognitive functioning, and emotion regulation when making their decisions about substance use. Also, future research could explore indirect pathways from tiredness to

substance use via intervening factors such as impaired emotion regulation, increased cravings, or negative affect.

Limitations of the current work include the brevity of the measures used and the generalizability of the samples. Greater precision regarding the exact times of most frequent substance use would be informative, as the current study was unable to determine exactly how late use may be occurring. It should also be noted that we only asked about time of most frequent use and not about concurrent levels of tiredness in each event. More nuanced information about tiredness in-the-moment of making substance use decisions could be gleaned from studies involving ecological momentary assessment and actigraphy monitoring. More information on lifestyle factors (e.g., employment, socioeconomic status, neighborhood characteristics) may be relevant—in particular, whether the individual is a shift-worker or on a nocturnal schedule. The social context for use—i.e., whether the substance use is occurring at home in private or socially in more public settings—should also be explored as a factor in substance use for sexual and gender minority individuals, given connections to "nightlife," and community or "scene" participation. Pressure from peers and/or partners regarding substance use and staying awake also warrants attention. More comprehensive measures of chronotype and circadian misalignment would be advantageous in future research. Future research could also explore the demographic differences noted in our analyses—e.g., that the later drinking time was more common in younger men, single men, GBM of color, and those from the hookup app and Facebook. Finally, we expect that similar dynamics may apply to other populations of interest, and would encourage future research in this direction.

Conclusion

In essence, this work has uncovered the possibility that, at times, GBM drink or use drugs when they are tired and perhaps do so *because* they are tired, to the further detriment of their self-regulatory capacities. Evidently, this spiral suggests a complex dynamic between tiredness and substance use which—though challenging on a study design level—highlights the need for research to employ appropriately complex time-sensitive methodologies. Further research is needed to examine whether the lateness of the hour when substance use occurs might be affecting the decisions that individuals are making about whether to have another drink or hit, or whether to engage in other health-compromising behaviors such as sexual risk-taking (which also commonly occurs at night; e.g., Millar, Starks, Rendina, & Parsons, 2018), eating fast food, or driving while intoxicated. Exploring the temporal patterns of substance use among GBM (as well as other populations) and their intersection with chronotype and thus circadian misalignment, offers new and valuable knowledge regarding risk factors in substance use and could help to develop interventions to improve the individual's ability to manage their substance use and associated behaviors.

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Public Significance Statement:

This study uncovers the finding that, among gay and bisexual men, alcohol and drug use most commonly occurs at night, suggesting that many individuals are making substance use decisions when they may be suffering from the deleterious effects of tiredness. Our finding that many men use substances to combat their tiredness further highlights the importance of considering tiredness and poor sleep health, as risk factors in substance use.

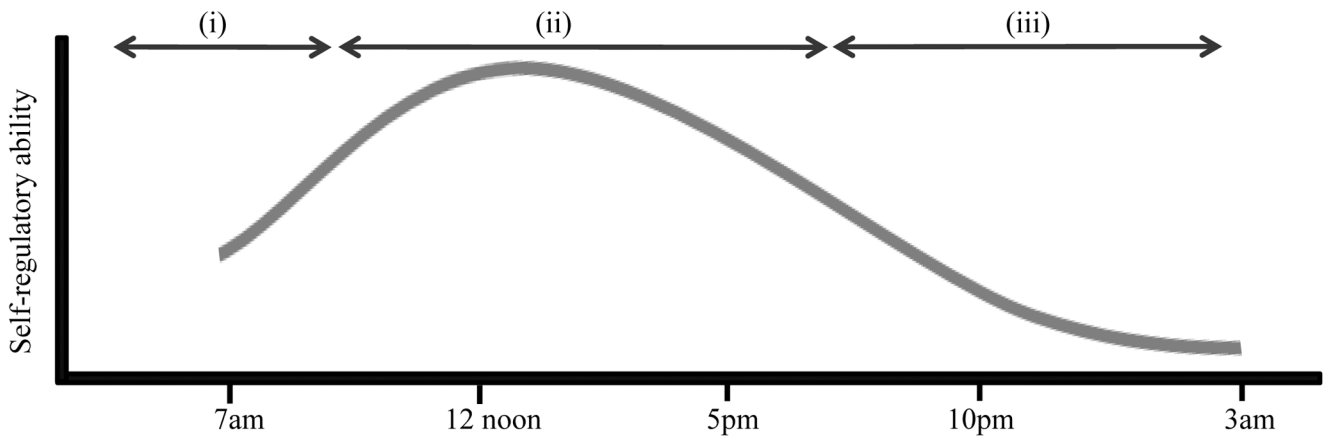

Figure 1.

Depiction of how circadian misalignment may apply to substance use for a hypothetical individual with an intermediate chronotype. (i) Circadian trough or dip, and also a timespan when substance use opportunities are typically rare. (ii) Circadian peak or prime, and also a timespan when substance use opportunities are typically rare. (iii) Circadian trough or dip, *but* also a timespan when substance use opportunities are most frequently encountered (and thus when circadian misalignment applies). Note: the grey line is expected to shift left for a morning type and to shift right for an evening type.

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Table 1.

Demographics for Study 1 and Comparisons by Time of Peak Drinking and Peak Club/Party Drug Use

		Peak Alcohol Use, *N* = 2814				Peak Drug Use, *N* = 449			
Demographics	**Total**	**Day**	**Evening**	**9pm onwards**		**Day**	**Evening**	**9pm onwards**	
	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**	**Test Statistic**	***n* (%)**	***n* (%)**	***n* (%)**	**Test Statistic**
Overall	2814 (100)	69 (2.5)	1301 (46.2)	1444 (51.3)		41 (9.1)	71 (15.8)	337 (75.1)	
Race and Ethnicity									
Black	254 (9.0)	10 (3.9)	89 (35.0)	155 (61.0)[a]		7 (14.3)	9 (18.4)	33 (67.3)	
Latino	509 (18.1)	8 (1.6)	166 (32.6)	335 (65.8)[a]	$\chi^2(6) = 100.81^{***}$	11 (10.8)	9 (8.8)	82 (80.4)	$\chi^2(6) = 9.18$
White	1768 (62.8)	44 (2.5)	940 (53.2)	784 (44.3)[b]		21 (8.3)	47 (18.7)	184 (73.0)	
Multiracial/Other	283 (10.1)	7 (2.5)	106 (37.5)	170 (60.1)[a]		2 (4.3)	6 (13.0)	38 (82.6)	
Sexual Identity									
Gay	2315 (82.3)	50 (2.2)	1078 (46.6)	1187 (51.3)	$\chi^2(2) = 4.86$	28 (7.4)	54 (14.4)	294 (78.2)[a]	$\chi^2(2) = 13.30^{**}$
Bisexual	499 (17.7)	19 (3.8)	223 (44.7)	257 (51.5)		13 (17.8)	17 (23.3)	43 (58.9)[b]	
Relationship Status									
Single	1756 (62.4)	44 (2.5)	734 (41.8)	978 (55.7)[a]	$\chi^2(2) = 37.37^{***}$	17 (6.0)[a]	51 (18.0)	216 (76.1)	$\chi^2(2) = 10.73^{**}$
Partnered	1058 (37.6)	25 (2.4)	567 (53.6)	466 (44.0)[b]		24 (14.5)[b]	20 (12.1)	121 (73.3)	
HIV Status									
Negative/Unknown	2351 (83.5)	55 (2.0)	1077 (45.8)	1219 (51.9)	$\chi^2(2) = 2.09$	30 (9.1)	43 (16.2)	245 (74.7)	$\chi^2(2) = 0.11$
Positive	463 (16.5)	14 (3.0)	224 (48.4)	225 (48.6)		11 (9.1)	18 (14.9)	92 (76.0)	
Education									
Less than degree	1451 (51.6)	48 (3.3)	592 (40.8)	811 (56.2)[a]		29 (10.5)	44 (15.9)	204 (73.6)	
4-year degree	813 (28.9)	14 (1.7)	400 (49.2)	399 (49.1)[b]	$\chi^2(4) = 46.77^{***}$	9 (7.2)	17 (13.6)	99 (79.2)	$\chi^2(4) = 3.12$
Graduate degree	550 (19.5)	7 (1.3)	309 (56.2)	234 (42.5)[c]		3 (6.4)	10 (21.3)	34 (72.3)	
Recruitment Source									
Hookup App	1550 (55.1)	33 (2.1)	617 (39.8)	900 (58.1)[a]		20 (7.4)	46 (17.1)	203 (75.5)	
Hookup Site	614 (21.8)	17 (2.8)	358 (58.3)	239 (38.9)[b]	$\chi^2(6) = 84.78^{***}$	10 (12.7)	15 (19.0)	54 (68.4)	$\chi^2(6) = 6.36$
Porn Sites	318 (11.3)	10 (3.1)	182 (57.2)	126 (39.6)[b]		4 (10.0)	5 (12.5)	31 (77.5)	
Facebook	332 (11.8)	9 (2.7)	144 (43.4)	179 (53.9)[a]		7 (11.5)	5 (8.2)	49 (80.3)	

Demographics	Total	Peak Alcohol Use, *N* = 2814				Peak Drug Use, *N* = 449			
		Day	Evening	9pm onwards	Test Statistic	Day	Evening	9pm onwards	Test Statistic
	n (%)	*n* (%)	*n* (%)	*n* (%)		*n* (%)	*n* (%)	*n* (%)	
Chronotype									
Morning Type	794 (28.2)	30 (3.8)	500 (63.0)	264 (33.2)[a]		15 (17.6)	15 (17.6)	55 (64.7)[a]	
Intermediate Type	422 (15.0)	8 (0.3)	199 (47.2)	215 (50.9)[b]	$\chi^2(4) = 157.61^{***}$	6 (8.7)	8 (11.6)	55 (79.7)[b]	$\chi^2(4) = 11.10^{*}$
Evening Type	1598 (56.8)	31 (1.9)	602 (37.7)	965 (60.4)[c]		20 (6.8)	48 (16.3)	227 (76.9)[b]	
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*		*M (SD)*	*M (SD)*	*M (SD)*	
Age (years)	37.7 (13.3)	40.6 (15.8)[a]	42.0 (13.7)[b]	33.8 (11.6)[c]	$F(2,2811) = 144.6^{***}$	34.9 (11.0)[a]	38.7 (12.1)[b]	34.3 (11.3)[a]	$F(2,446) = 4.66^{*}$

Note. Within columns within variables, different superscripts signify that proportions among groups differ significantly. For age, different superscripts signify that age among groups differs significantly.

*$p < 0.05$.

**$p < 0.01$.

***$p < 0.001$.

Table 2

Logistic Regressions Predicting Peak Time of Alcohol Use and Club/Party Drug Use from 9pm Onwards (vs. Day/Evening)

	Model 1: *N* = 2814 Peak Alcohol Use 9pm Onwards				**Model 2: *N* = 449 Peak Drug Use 9pm Onwards**			
	B	**AOR**	***p***	**95% CI for AOR**	***B***	**AOR**	***p***	**95% CI for AOR**
Constant	−1.10	0.33	<0.001		0.19	1.20	0.61	
Race and Ethnicity (ref. White)								
Men of Color	0.50	1.64	<0.001	[1.38, 1.95]	0.19	1.21	0.43	[0.76, 1.91]
Recruitment Source (ref. Hookup/Porn Sites)								
Hookup App & Facebook	0.37	1.45	<0.001	[1.21, 1.73]	0.17	1.19	0.50	[0.72, 1.95]
Relationship Status (ref. Partnered)								
Single	0.27	1.31	<0.01	[1.11, 1.54]	0.15	1.16	0.52	[0.74, 1.81]
Education (ref. Less than college degree)								
4-year college degree	−0.10	0.91	0.30	[0.75, 1.09]	0.47	1.60	0.08	[0.94, 2.71]
More than college degree	−0.16	0.85	0.14	[0.68, 1.05]	−0.05	0.96	0.90	[0.47, 1.94]
Age	−0.03	0.97	<0.001	[0.96, 0.97]	−0.02	0.98	0.10	[0.96, 1.00]
Chronotype (ref. Morning Type)								
Intermediate Type	0.52	1.68	<0.001	[1.30, 2.17]	0.76	2.15	0.05	[1.01, 4.58]
Evening Type	0.93	2.53	<0.001	[2.09, 3.06]	0.56	1.75	0.05	[1.01, 3.03]
Model Statistics:	Model $\chi^2(8) = 429.73$, $p < 0.001$				Model $\chi^2(8) = 14.55$, $p < 0.07$			
	Hosmer & Lemeshow: $\chi^2(8) = 7.12$, $p = 0.52$				Hosmer & Lemeshow: $\chi^2(8) = 16.18$, $p = 0.04$			
	Percentage correctly classified = 66.4				Percentage correctly classified = 75.3			

Note. AOR = adjusted odds ratio; CI = confidence interval; ref. = referent.

Table 3.

Demographics for Study 2 and Comparisons by Use of Alcohol or Drugs to Stay Awake

Demographics	Total	Alcohol to Stay Awake			Total	Drugs to Stay Awake		
		No	Yes	Test Statistic		No	Yes	Test Statistic
	n (%)	*n* (%)	*n* (%)		*n* (%)	*n* (%)	*n* (%)	
Overall	927 (100)	435 (46.9)	492 (53.1)		401 (100)	293 (73.1)	108 (26.9)	
Race and Ethnicity								
Black	113 (12.2)	59 (52.2)	54 (47.8)[a]		42 (10.5)	29 (69.0)	13 (31.0)	
Latino	162 (17.5)	60 (37.0)	102 (63.0)[b]	$\chi^2(3) = 14.71^{**}$	71 (17.7)	53 (74.6)	18 (25.4)	$\chi^2(3) = 0.55$
White	570 (61.5)	287 (50.4)	283 (49.6)[a]		250 (62.3)	184 (73.6)	66 (26.4)	
Multiracial/Other	82 (8.8)	29 (35.4)	53 (64.6)[b]		38 (9.5)	27 (71.1)	11 (28.9)	
Sexual Identity								
Gay	886 (95.6)	412 (46.5)	474 (53.5)	$\chi^2(1) = 1.45$	376 (93.8)	273 (72.6)	103 (27.4)	$\chi^2(1) = 0.65$
Bisexual	41 (4.4)	23 (56.1)	18 (43.9)		25 (6.2)	20 (80.0)	5 (20.0)	
Relationship Status								
Single	442 (47.7)	214 (48.4)	228 (51.6)	$\chi^2(1) = 0.75$	204 (50.9)	144 (70.6)	60 (29.4)	$\chi^2(1) = 1.30$
Partnered	485 (52.3)	221 (45.6)	264 (54.4)		197 (49.1)	149 (75.6)	48 (24.4)	
Income								
Below $50K	461 (49.7)	220 (50.6)	241 (49.0)	$\chi^2(1) = 0.63$	181 (45.1)	127 (70.2)	54 (29.8)	$\chi^2(1) = 1.41$
$50K or above	466 (50.3)	215 (49.4)	251 (51.0)		220 (54.9)	166 (75.5)	54 (24.5)	
Education								
Less than degree	364 (39.3)	171 (47.0)	193 (53.0)		168 (41.9)	124 (73.8)	44 (26.2)	
4-year degree	284 (30.6)	123 (43.3)	161 (56.7)	$\chi^2(2) = 2.95$	116 (28.9)	82 (70.7)	34 (29.3)	$\chi^2(2) = 0.48$
Graduate degree	279 (30.1)	141 (50.5)	138 (49.5)		117 (29.2)	87 (74.4)	30 (25.6)	
Chronotype								
Morning Type	194 (20.9)	132 (68.0)	62 (32.0)[a]		72 (18.0)	58 (80.6)	14 (19.4)	
Intermediate Type	469 (50.6)	276 (58.8)	193 (41.2)[b]	$\chi^2(2) = 7.19^{*}$	204 (50.9)	152 (74.5)	52 (25.5)	$\chi^2(2) = 5.09$
Evening Type	264 (28.5)	148 (56.1)	116 (43.9)[b]		125 (31.2)	83 (66.4)	42 (33.6)	
	M (SD)	*M (SD)*	*M (SD)*	$t(925) = 9.40^{***}$		*M (SD)*	*M (SD)*	$t(399) = 6.59^{***}$

Demographics	Total	Alcohol to Stay Awake			Total	Drugs to Stay Awake		
		No	Yes	Test Statistic		No	Yes	Test Statistic
	n (%)	*n* (%)	*n* (%)		*n* (%)	*n* (%)	*n* (%)	
Age (range 19-81)	40.8 (13.5)	45.0 (14.0)	37.1 (11.7)		42.3 (14.1)	45.0 (14.2)	35.0 (10.8)	
AUDIT-C (range: 0-12)	*n* = 923	3.3 (1.8)	4.6 (2.1)	$t(922) = 10.19^{***}$	-	-	-	-
DAST (range: 0-9)	-	-	-	-	*n* = 119	1.72 (1.8)	2.76 (2.0)	$t(117) = 2.74^{**}$

Note. Within rows within variables, cells with different superscripts differ significantly. Alcohol variable combines both alcohol and alcohol mixed with energy drinks. AUDIT-C = Alcohol Use Disorders Identification Test-Consumption; DAST = Drug Abuse Screening Test.

*$p < 0.05$;

**$p < 0.01$;

***$p < 0.001$.

Table 4

Logistic Regressions Predicting the Motivation to Use Alcohol and Drugs to Stay Awake

	Model 1: *N* = 927 Use of Alcohol[a] to Stay Awake				Model 2: *N* = 401 Use of Drugs to Stay Awake			
	B	**AOR**	***p***	**95% CI for AOR**	***B***	**AOR**	***p***	**95% CI for AOR**
Constant	−0.27	0.76	0.19		−1.23	0.29	<0.01	
Race and Ethnicity (ref. White and Black)								
Latino and Other/Multiracial	0.32	1.38	0.05	[1.00, 1.90]	−0.56	0.57	0.04	[0.33, 0.99]
Relationship Status (ref. Partnered)								
Single	0.15	1.16	0.30	[0.88, 1.53]	0.28	1.33	0.24	[0.82, 2.14]
Education (ref. less than college degree)								
4-year college degree	0.07	1.08	0.67	[0.77, 1.51]	0.24	1.27	0.42	[0.71, 2.26]
More than college degree	−0.25	0.78	0.16	[0.55, 1.10]	0.31	1.36	0.32	[0.74, 2.48]
Income (ref. less than $50K)								
$50K or more	0.44	1.55	<0.01	[1.15, 2.10]	0.15	1.17	0.56	[0.70, 1.96]
Age	−0.03	0.97	<0.001	[0.96, 0.97]	−0.07	0.93	<0.001	[0.91, 0.96]
Chronotype (ref. Morning Type)								
Intermediate Type	0.06	1.06	0.74	[0.74, 1.53]	−0.21	0.81	0.57	[0.69, 1.67]
Evening Type	0.12	1.13	0.58	[0.74, 1.71]	0.06	1.06	0.89	[0.49, 2.27]
Model Statistics:	Model $\chi^2(9) = 98.76$, $p < 0.001$				Model $\chi^2(8) = 50.93$, $p < 0.001$			
	Hosmer & Lemeshow: $\chi^2(8) = 6.91$, $p = 0.55$				Hosmer & Lemeshow: $\chi^2(8) = 7.23$, $p = 0.51$			
	Percentage correctly classified = 65.3				Percentage correctly classified = 74.1			

Note. AOR = adjusted odds ratio; CI = confidence interval; ref. = referent.

[a] Alcohol variable combines both alcohol and alcohol mixed with energy drinks.