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Does Hangover Influence the Time to Next Drink? An Investigation Using Ecological Momentary Assessment

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Abstract

BACKGROUND—Measures of hangover are associated with current and future problematic alcohol use. At present, it is not known whether these associations reflect any direct influence of hangover events on near-term drinking behaviors. The current study aimed to determine whether hangover following a drinking episode influences time to next drink (TTND), and, if so, to determine the direction of this effect and identify any moderating personal or contextual factors.

METHODS—Community-recruited, frequent drinkers oversampled for current smoking (N=386) carried electronic diaries for 21 days, reporting on drinking behaviors and other experiences. Survival analysis was used to model data from 2,276 drinking episodes, including 463 episodes that were followed by self-reported hangover in morning diary entries.

RESULTS—When tested as the sole predictor in a survival model, hangover was associated with increased TTND. The median survival time was approximately 6 hours longer after episodes with hangovers compared to those without. In a multivariate model, hangover was only significant in the presence of interaction effects involving craving at the end of the index drinking episode and the occurrence of financial stressors. Additional predictors of TTND in the final multivariate model included age, lifetime alcohol use disorder diagnosis, typical drinking frequency, day of the week, and morning reports of craving, negative affect, and stressors after the index episode. There was no association between morning reports of hangover and contemporaneous diary ratings of likelihood of drinking later the same day.

CONCLUSIONS—The findings suggest that hangover has, at best, a modest or inconsistent influence on the timing of subsequent alcohol use among frequent drinkers.

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INTRODUCTION

Hangover is a common adverse effect of excessive drinking (Verster, et al., 2010a). Measures of hangover have been shown to be associated with current and future problematic alcohol use (Piasecki, Robertson, & Epler, 2010a; Piasecki, Sher, Slutske, & Jackson, 2005; Rohsenow et al., 2012). At present, we do not know whether these associations reflect a direct influence of hangovers on the timing of subsequent alcohol use.

Because hangover represents an aversive experience contingent upon heavy drinking, it seems natural to infer that hangovers punish overindulgence and discourage future alcohol consumption. Consistent with this hypothesis, drinkers report hangover avoidance as a reason for limiting alcohol use (Smith, Bookner, and Dreher, 1988). Variants of *ADH1B* and *ALDH2* genes that result in aversive flushing responses to alcohol consumption have been associated with both decreased AUD risk and more severe anticipated hangover symptoms after drinking (Wall, Horn, Johnson, Smith, & Carr, 2000; Wall, Shea, Luczak, Cook, & Carr, 2005). Rodriguez and Span (2008) found that symptoms of attention-deficit hyperactivity disorder were cross-sectionally associated with more frequent drinking, but only among individuals who anticipated experiencing low hangover symptoms after consuming 4 standard drinks. Rohsenow, et al., (2012) found that higher hangover severity the morning after an alcohol challenge was associated with experiencing fewer drinking problems 1–4 years later. All of these findings suggest a heightened susceptibility to hangover affords protection from problem drinking, as would be expected in a punishment-based account.

On the other hand, negative outcomes of drinking, including hangover, frequently cluster in the same "repeat offenders" (e.g., Mallett, Marzell, Varvil-Weld, Turrisi, Guttman, & Abar, 2011; Robertson, et al., 2012). The fact that some drinkers repeatedly experience hangovers may suggest the syndrome is either not an effective punisher (at least for some individuals), or that it has a short-lived punishing effect. Although it seems axiomatic that hangovers should be aversive, young adults frequently perceive them to be neutral or positive experiences (Fjær, 2012; Mallett, Bachrach, & Turrisi, 2008), and there are measurable individual differences in willingness to experience a hangover (Mallett, Varvil-Weld, Turrisi, & Read, 2011).

It is also conceivable that hangover could accelerate problematic alcohol involvement by encouraging "hair of the dog" drinking to alleviate hangover symptoms. Surveys of college students have suggested that drinking to relieve hangover has been tried by 25–56% of drinkers, and that this behavior is associated with heavier alcohol consumption and higher AUD symptom counts (Hunt-Carter, Slutske, & Piasecki, 2005; Verster, 2009). Although hangover is clearly not identical to the alcohol withdrawal syndrome (Penning, van Nuland, Fliervoet, Olivier, & Verster, 2010; Prat, Adan, & Sánchez-Turet, 2009), some theorists have speculated that hangover might be understood as a form of acute withdrawal or a subtle indicator of risk for physical dependence (Earleywine, 1993a; 1993b; Newlin & Pretorious, 1990; Piasecki, et al., 2005). According to this account, a greater sensitivity to hangover should be related to AUD risk. This association could be mediated through drinking to relieve hangovers, but hangover also be a non-causal marker of dependence liability (Piasecki, et al, 2005). Congruent with this conjecture, a family history of alcoholism has sometimes been associated with greater hangover frequency and sensitivity (e.g., Newlin & Pretorious, 1990; Piasecki, et al., 2005; Piasecki, et al., 2010b; Slutske, Piasecki, & Hunt-Carter, 2003; Span & Earleywine, 1999).

Although discrepant hypotheses concerning a link between hangover and subsequent drinking appear plausible, this question has yet to be assessed directly using a micro-longitudinal research design. To our knowledge, there has only been one examination of the interplay between experiences on the morning after drinking and subsequent drinking behavior on a day-to-day basis. Using data from two Ecological Momentary Assessment (EMA) studies, Muraven, Collins, Mosheimer, Shiffman, & Paty (2005) found that violating a self-imposed drinking limit was associated with guilt, distress and hangover symptoms the next morning. Higher morning distress forecast intentions to drink and amount of alcohol consumed later the same day, even when hangover symptoms were covaried. These findings indicate morning-after distress stemming from excessive drinking may interfere with attempts to regulate consumption later the same day or motivate drinking to relieve distress. However, the focus of this work was on limit violations and remorse; the effects of hangover per se on later drinking were not investigated.

In the current study, we use records from an EMA investigation to test the motivational impact of hangover events in two ways. First, and most critically, we examine whether hangover following an index drinking episode significantly predicts time to the next drink (TTND) in a survival analysis. A secondary strategy investigates associations between hangovers and morning reports of the likelihood of drinking later the same day.

The goals of the current research were exploratory and descriptive – we sought to evaluate whether hangover following a drinking episode has a unique effect on time to next drink, and, if so, to determine the direction of this effect and identify any personal or contextual factors that might moderate it. More broadly, we expected that addressing this understudied question would contribute to the development of theory needed to interpret associations between hangover measures and AUD.

MATERIALS AND METHODS

Participants

Participants were recruited from the Columbia, Missouri community via print advertisements, mass emails, and posted flyers. This study has been described in prior reports (Piasecki et al., 2012a; Piasecki, et al., in press; Piasecki, et al., 2011; Piasecki, Wood, Shiffman, Sher, & Heath, 2012b; Robertson, et al., 2012). Briefly, participants were required to be 18 or older, report drinking alcohol at least once per week, and to either (a) smoke at least one cigarette per week on average, or (b) have smoked less than 20 cigarettes in their lifetime and none in the last year. A total of 404 participants completed at least one diary report. The current analyses used data from 386 participants who had at least one drinking episode with a corresponding morning report (containing the hangover assessment). Participants were primarily White (83%), and college age or slightly older (*M* = 23.5, *SD* = 7.5, range 18–70). By design, roughly two-thirds of participants were current smokers (64%), with approximately equal numbers of men and women (51% male). Table 1 presents additional sample characteristics.

Procedure

Participants completed a questionnaire battery during a baseline visit. At a subsequent visit, they received training in the use of the diary and were issued a diary device (Palm m500, Palm Inc., Sunnyvale, CA) programmed with customized software (invivodata inc., Pittsburgh, PA). Participants carried the diary for 21 days during which they were scheduled for 4 in-person visits for technical support and data backup.

Baseline Questionnaire Measures

Demographics—Responses to a demographic questionnaire were used to create dichotomous variables indexing participants' sex (1 = males, 0 = females), race/ethnicity (1 = white, 0 = other), marital status (1 = single, never married, 0 = other) and parental status (1 = no children, 0 = 1 or more children). These variables were investigated as covariates because they are related to risk for alcohol use and AUD (e.g., Grant, et al., 2004) and because sex and age have been related to hangover occurrence (Piasecki, et al., 2005; Piasecki, et al., 2010a; Tolstrup, Stephens, & Grønbæk, 2013).

Family history of alcohol problems—Adapted versions of the Short Michigan Alcoholism Screening Test (SMAST) were used to assess alcohol abuse among participants' biological fathers (F-SMAST) and mothers (M-SMAST; Crews & Sher, 1992). Participants were considered to be positive for a family history of alcohol problems if either their F-SMAST or M-SMAST total score was 5 or higher (Crews & Sher, 1992). A family history of alcoholism is associated with heavy drinking (e.g., Sher, Walitzer, Wood, & Brent, 1991), and has been related to hangover in some studies (e.g., Newlin & Pretorious, 1990; Piasecki, et al., 2005; Piasecki, et al, 2010b; Span & Earleywine, 1999).

Alcohol Sensitivity—The Self-Rating of the Effects of Alcohol form (SRE; Schuckit, Smith, & Tipp, 1997a) asks respondents to indicate the number of drinks needed to experience four separate effects (feeling different, becoming dizzy, incoordination, and passing out) during three periods (most recent 3 months, period of heaviest drinking, and first five times drinking). An overall sensitivity score was calculated by taking the average number of drinks across all endorsed effects and periods (Schuckit, et al., 1997b). Participants with higher SRE scores drank more heavily and were more likely to report a hangover event during this study (Piasecki, et al., 2012a).

Drinking motives—Drinking motives were assessed using the Drinking Motives Questionnaire-Revised (DMQ-R; Cooper, 1994), which assesses two domains of approach motivation (social and enhancement) and two avoidance-related domains (coping and conformity). These measures were related to alcohol consumption and appraised alcohol effects in this sample (Piasecki, et al., in press).

Alcohol use, alcohol consequences, and substance use diagnoses—Typical alcohol consumption patterns and negative consequences were assessed using the 10-item Alcohol Use Disorders Identification Test (Saunders, Aasland, Babor, De La Fuente & Grant, 1993). Item 1, assessing typical frequency of alcohol consumption, was examined alone. Additionally, a total AUDIT score was calculated for all 10 items. Lifetime alcohol and drug abuse and dependence diagnoses according to the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV, APA, 1994) criteria were assessed using a computerized version of the Diagnostic Interview Schedule for DSM-IV (C-DIS; Blouin, Perez, & Blouin, 1988). Abuse and dependence diagnoses were combined. We expected that greater alcohol and drug involvement would be associated with hangover occurrence and shorter TTND.

Nicotine dependence—Level of nicotine dependence was assessed using the Fagerström Test for Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker & Fagerström, 1991). Non-smokers were assigned a score of zero. We included this covariate because we oversampled smokers, smoking was related to drinking at the momentary level (Piasecki, et al., 2011), and smoking has been related to hangover in prior research (Piasecki, et al., 2010b; Jackson, Rohsenow, Piasecki, Howland, & Richardson, 2013).

Impulsivity—The Barratt Impulsiveness Scale (BIS; Patton, Stanford, & Barratt, 1995) assesses a variety of specific domains of impulsivity. To reduce the number of variables in the predictor set, only the total scale score was used in the current analyses. We considered impulsivity as a covariate because it is related to heavy episodic drinking (e.g., Henges & Marczinski, 2012) and could moderate drinking to relieve hangover.

Diary Measures

The diary functioned as an alarm clock, and participants were asked to complete a morning report upon waking each day. Participants were instructed to initiate a recording each time they finished the first drink in an episode and to respond to prompted, time-based follow-ups tied to completion of the first drink (drinking follow-ups, or DFUs). The first DFU report occurred 30 minutes after the initial drink report. This was followed by two additional DFUs at 60-minute intervals. Each time one or more new drinks was reported in a DFU, the follow-up sequence was extended by appending an additional DFU 60 minutes after the last currently scheduled alarm. Delivery of DFUs continued until either the participant completed a bedtime report or reported zero drinks at two consecutive DFUs.

Hangover—Morning reports assessed whether or not participants had consumed any alcohol during the previous night. If participants answered affirmatively, they were asked how many total drinks they consumed as well as whether they were currently experiencing a hangover (“Do you have a hangover?” yes/no). The total number of hangovers reported for each participant was calculated for the entire study period; a dichotomous indicator of ever reporting a hangover during the study was also created. In all, 463 hangover events were recorded. Table 1 presents participant characteristics as a function of any hangover.

Likelihood of drinking tonight—In each morning report, participants were asked to rate the likelihood that they would drink that night using a Likert scale with 1 indicating 'Definitely not' and 5 indicating 'Definitely plan to drink'.

Drinking events—User-initiated drinking reports were used to identify the start of a drinking episode. Other types of diary records (e.g., random prompts, cigarette reports) included a question asking whether the participant had consumed alcohol in the past hour. Endorsement of drinking triggered DFUs. These reports were also used to identify the start of a drinking episode.

Subjective states—Participants rated how much they experienced each of 11 states in the past 15 minutes using a Likert scale (1= 'Not at all,' 5= 'Extremely'). *Enthusiasm*, *excited*, and *happy* were combined to form a composite of positive affect ($\alpha = 0.89$), *distress* and *sadness* were combined to index negative affect ($\alpha = 0.72$), and *sluggish*, *buzzed*, *dizzy*, *headache*, and *nauseous* were combined into a composite index of physical effects ($\alpha = 0.68$). *Crave a drink* was retained as a single item. The analyses examined these measures at two assessment occasions: during the final DFU report logged during the drinking episode and in the corresponding morning report. Morning-reported symptoms were especially important covariates, as they permitted investigating whether any association between hangover and TTND depended upon the intensity of hangover discomfort.

Stressors—Morning reports asked participants whether or not stressors occurred since the last morning report in 5 domains (work/school, finances, interpersonal/romantic, health, and other) and then for an overall rating of how much stress has weighed on them (1 = 'Not at all,' 5 = 'Extremely'). Stress is related to both drinking and alcohol problems, at least for some drinkers (e.g., Greeley & Oei, 1999), and daily stressors could moderate the hangover-TTND relation.

Time to next drink—TTND was calculated as the time in hours elapsed from the last DFU for an index drinking episode until the initiation of a subsequent drinking episode. When an index drinking episode was not followed by another drinking episode during the EMA assessment period, the TTND variable was right censored at the time the study exit (269 episodes). To serve as an index episode, a drinking event had to be accompanied by both: (a) one or more valid report(s) during the drinking episode, and (b) a completed morning report (containing the hangover assessment) from the next day. Only 2,276 of 3,087 episodes (73%) met these criteria. Diary reports of drinking were used to calculate the survival time since the preceding index episode, even if they could not be counted as index events.

Other diary-derived measures—The total number of drinking days reported via the diary during the study period was calculated for each participant. Day of the week was coded as the day in which the index episode was initiated. A set of six dummy variables were created with Monday as the reference day. Alcohol use and hangovers are strongly tied to the weekly calendar (e.g., Jackson, et al., 2013).

Total number of drinks reported during each drinking episode was calculated assuming one drink for each event triggering the DFUs and summing across DFU reports of the number of drinks consumed since last report. Ideally, this should yield an estimate that is identical to participants' morning report of the prior night's drink total. In practice, however, these estimates were often discrepant, and it is not clear that one or the other should be consistently more accurate. Across all drinking episodes, these two estimates were moderately correlated (r = .56, p <.001). The mean and median discrepancies between the two reports for the same episode were 0.93 and 2.0, respectively, indicating slightly higher totals captured in the real-time reports. Higher drink totals were expected to be associated with hangover endorsement.

The number of cigarettes during the drinking episode was calculated by summing reported cigarettes across the DFU-triggering record and associated DFUs. Non-smokers were assumed to have smoked zero cigarettes. Heaviness of smoking while drinking is related to the occurrence and intensity of next-day hangover (Jackson, et al., 2013).

The time elapsed from the initiation of the drinking episode until the final DFU was used as an indicator of the length of each episode. Longer episodes could be related to hangover risk (e.g., by curtailing sleep) or be an indicator of impaired control over alcohol intake.

RESULTS

Predictors of Hangover Events

Univariate associations of person- and day-level predictors with hangover events were evaluated in generalized linear mixed models for dichotomous outcomes featuring random intercepts (SAS Software PROC GLIMMIX, SAS Institute, Inc, Cary, NC). Odds ratios from these analyses are presented in Table 2. Notably, there was no association between hangover and contemporaneous morning reports of the likelihood of drinking later in the day.

Hangover was associated with being younger, single, without children, having an AUD and higher scores on the AUDIT, SRE, BIS, and DMQ-R coping, social, and enhancement scales. Surprisingly, higher FTND scores and logging more drinking episodes during the study period were each associated with decreased hangover likelihood.

At the day level, hangover events were associated with consuming more drinks during the index episode. To characterize levels of alcohol exposure, we computed multilevel regression analyses with hangover as the predictor and number of drinks as the outcome measure. Estimated marginal means for number of drinks captured in real time indicated that participants consumed an average of 9.26 drinks in episodes followed by hangover compared to 6.5 drinks in episodes not followed by hangover. Corresponding estimates from morning reports were 9.27 and 5.27 drinks, respectively.

Smoking more cigarettes during the drinking episode, and experiencing higher levels of positive affect, physical effects, and drink craving at the end of the episode were each associated with hangover. In contrast, hangovers were associated with decreased positive affect, increased negative affect, and greater physical effects the morning after drinking. Hangovers were more likely to occur following drinking episodes on Wednesdays, Thursdays, Fridays, and Saturdays (relative to Mondays). Morning reports completed on hangover days occurred significantly later than those on non-hangover days.

Univariate Models Predicting Time to Next Drink

Associations with time to next drink (TTND) were examined using Cox regression survival analyses with shared frailty (the equivalent of random effects, appropriate to account for the clustering of drinking episodes within persons; PROC PHREG, SAS Software ver. 9.3). Results from univariate analyses are presented in Table 2. Considered alone, hangover significantly delayed TTND, (HR = 0.86, 95% CI = 0.75 to 0.98, $p = .020$). The median survival time was approximately 6 hours longer after index drinking episodes with hangover (44.0 hours) compared to those without hangover (38.4 hours; Figure 1).

As expected, higher ratings of likelihood of drinking later in the day were strongly associated with decreased TTND (HR = 1.48, 95% CI = 1.42 to 1.53, $p < .001$). Shorter TTND was observed among participants who were older, married, current smokers, higher in nicotine dependence, had an AUD, scored highly on the AUDIT, drank more frequently, had higher coping motives, and reported more hangovers during the study. Stronger social motives were associated with longer TTND.

At the day-level, decreased TTND was related to work/school stressors, smoking more cigarettes during the index episode, and elevations in morning-reported alcohol craving. Reporting more total drinks in the morning report was associated with decreased TTND, but the real-time drink tally was not significant. TTND was extended after morning reports completed at later times of day. Also, drinking on Thursdays and Fridays was associated with decreased TTND, while TTND was increased after episodes occurring on Saturdays or Sundays (all relative to the Monday reference). Morning negative affect was associated with increased TTND.

Multivariate Prediction of Time to Next Drink

To reduce the total number of variables tested in multivariate models, the predictors were grouped into three person-level blocks (demographics, substance-related, and drinking motives/impulsivity), and four day-level blocks (timing, drinking episode characteristics, stressors, and morning-after characteristics). Within the demographics block, being single and having no children were highly correlated ($r = 0.83$) and therefore only marital status was included in multivariate models. Within the substance-related block, paternal and maternal family history were substantially correlated ($r = 0.51$) and therefore a composite indicating any family history of alcohol problems was used. Each block was tested separately to determine which variables, including two-way interactions with hangover should be retained for the overall multivariate model. First all variables in the block and their interaction with hangover were included. Non-significant ($p < .05$) interactions were removed one at a time, starting with the interaction with the largest *p*-value. Once all non-significant interactions were removed, non-significant main-effects ($p < .10$) were removed one at a time, starting with the main-effect with the largest *p*-value.

The final model, constructed by entering all predictors that survived trimming criteria in block-specific models, is summarized in Table 3. TTND varied by day of the week of the index episode. Main effects were also observed for age, drinking frequency, AUD diagnosis, work/school stressor, and levels of morning negative affect and craving. The main effect for hangover in the final model switched direction and was not significant (HR = 1.34, 95% CI = 0.98 to 1.84, $p = .068$). This was qualified by two significant interactions.

An interaction between hangover and craving for alcohol at the end of the drinking episode indicated that, as alcohol craving increased, hangover was associated with larger delays in TTND (interaction HR = 0.91, 95% CI = 0.83 to 0.99, $p = .042$). This effect was explored using stratified hazard ratios for hangover computed at varying levels of the 1–5 craving rating scale. These HR estimates ranged from 1.08 to 0.74, with significant effects for hangover delaying TTND at craving levels of 4 (HR = 0.81, 95% CI = 0.68 to 0.97) and 5 (HR = 0.74, 95% CI = 0.57 to 0.94). Figure 2 presents survival curves illustrating the interaction.

Hangover also interacted with the occurrence of a financial stressor (interaction HR = 0.68, 95% CI = 0.51 to 0.90, $p = .008$). Stratified hazard ratios indicated that hangover significantly delayed TTND in the presence of a financial stressor (HR = 0.73, 95% CI = 0.57 to 0.94) but was not associated with TTND in the absence of a stressor (HR = 1.08, 95% CI = 0.90 to 1.29). Figure 3 presents survival curves illustrating the interaction.

Because covarying the number of drinks (a hangover cause) and morning-reports of negative affect (a possible hangover effect) might have obscured the hangover measure's true association with TTND, we estimated an additional multivariate model excluding these two predictors. Results were essentially unchanged.

DISCUSSION

When considered as the sole predictor in a survival model, the presence of hangover after the index drinking event was associated with a small but significant delay in TTND (Table 2, Figure 1). Results of the final multivariate survival model suggested that occurrence of a hangover was not associated with TTND, except in the presence of interactions. Hangover separately interacted with craving level at the end of the index drinking episode and the onset of financial stressor in predicting TTND. Hangover delayed TTND when craving was intense at the end of a drinking episode, but not when craving was rated in the mid-range or lower (Figure 3). This could indicate that some individuals are more reactive to both the near-term incentive effects of alcohol (i.e., they have cravings and drink to excess) and the punishing effects of alcohol (i.e., they delay drinking after hangover). Another possibility is that some drinkers may go out for a "last hurrah" before a planned delay or interruption of drinking. Cravings during the last episode might reflect a savoring of the last drinking event before the anticipated hiatus. A third possibility could be that strong cravings at the end of a drinking episode are indicators of the capacity for successful self-regulation – that is, craving may result when environmental cues encourage further consumption but the drinker adheres to self-imposed drinking limits (cf. Muraven, et al., 2005; Tiffany, 1990). The finding that hangover delayed TTND when coupled with a financial stressor could indicate that the punishing aftereffects of drinking are easier to heed when there are independent forces, such as a compelling need to be frugal, that also discourage future drinking. Of course, these interaction effects could have arisen by chance, and so they should be eyed with caution until replicated.

As a complementary strategy, we tested whether hangovers were associated with contemporaneous reports of intention to drink later the same day. This association was not significant. Notably, higher morning estimates of same-day drinking likelihood were strongly associated with decreased TTND (Table 2). This corroborates the validity of the drinking likelihood ratings, adding weight to the absence of an association between hangover and reported drinking likelihood.

Learning theory would suggest that hangover might not be expected to directly influence subsequent drinking because it is a delayed consequence of drinking that is generally preceded by the positive, reinforcing effects of alcohol consumption. Hangovers were associated with more intense positive affect and physical effects at the end of the preceding drinking episode (Table 2). However, it is notable that the affective and physical effects experienced at the end of the drinking episode were themselves unrelated to TTND (Table 2). Thus, the effects of hangover were apparently not overshadowed by more proximal, rewarding alcohol effects.

Hangovers were more common among participants with AUD diagnoses and with more drinking problems as indexed by the AUDIT. The number of diary-reported hangovers during the study was associated with decreased TTND. These findings likely reflect the fact that frequent or problematic drinkers simply have more chances to develop hangover. Yet, they also suggest that hangover experiences can be construed as part of the AUD symptom constellation (Piasecki, et al., 2010a). In contrast with our findings from a previous diary study (Piasecki, et al., 2010b), parental alcohol problems were not associated with diary hangover and smokers were modestly less likely to report hangover compared to nonsmokers. Consistent with prior research, however, hangovers were associated with smoking more cigarettes during the drinking episode, day of the week (Jackson, et al., 2013), younger age (Piasecki, et al., 2005; Tolstrup, et al., 2013), and lower sensitivity to alcohol (Piasecki, et al., 2012a).

It is important to emphasize that we examined the behavioral consequences of hangovers *among drinkers who develop hangovers* when left to their own devices in their natural environments. This does not represent a comprehensive assessment of all possible motivational effects of hangovers. A lack of scientific interest in hangover cures has been attributed, in part, to ethical concerns that the discovery of an effective hangover cure would encourage binge drinking (Pittler, Verster, & Ernst, 2005; Verster & Penning, 2010). To the extent they suggest hangover events do not strongly or consistently affect time to next drink, the current findings partially assuage such concerns. However, the *threat* of hangover conceivably serves as a deterrent for some drinkers, encouraging careful and successful efforts to regulate alcohol consumption within a safe range. If so, the availability of an effective cure might remove the overhanging threat, encouraging a larger proportion of current drinkers to become less cautious about alcohol intake.

One potential explanation for the absence of stronger associations between hangover and TTND might be that the constructs of interest were not validly measured. This is unlikely given the fairly extensive amount of construct validity demonstrated by associations among the predictor set, TTND and hangover (Table 2). Another possibility is that hangovers significantly delay drinking for some individuals and hasten drinking among others. A mixture of subgroups with countervailing effects could account for the absence of a clear hangover-TTND relation in the full sample. We tested for potential moderation of hangover effects using a number of individual difference measures, finding no significant interactions, but future studies using different samples or measures might detect such effects. Finally, it could be argued that effects of hangover might be more evident using alternative outcome variables, such as self-reported likelihood of consuming 5 or more drinks tonight, actual number of drinks in subsequent episodes, or time to next binge drinking event. Instead of inspiring total avoidance of drink, hangovers may spur attempts to regulate the *quantity* consumed in subsequent episodes. This deserves investigation in future research.

Several limitations of this work should be considered. To achieve other aims of the broader research project, we deliberately recruited a disproportionate number of current smokers and required participants to be frequent drinkers. Young adults (ages 18–25) comprised the bulk of the sample. The current findings may not generalize to samples with different characteristics. Due to missing diary data, only 73% of the drinking episodes recorded during the study could be included as index episodes in the survival analysis. It is possible that missing episodes were attributable to hangover. The extent to which this biases the results is unknown. Participants tracked their drinks in real time and retrospectively reported the total number consumed the next morning. These indices were correlated but not identical. It was reassuring that hangover events were associated with higher drink totals reported via either method, but surprising that only morning reported drink total were associated with TTND (Table 2).

The current findings suggest that associations predicted by intuitively-plausible notions about hangover-related near-term modulation of drinking behaviors are not easily detected in ecological assessments. Hangover may discourage drinking, but the median survival time was increased by only a few hours in the univariate analysis in our sample. We conclude that theorizing about hangover-AUD relations need not be constrained by strong assumptions that hangover is either a potent and consistent punisher or a strong goad to relief drinking in frequent drinkers. The prospective associations between hangover frequency and severity and problematic drinking may not be mediated by near-term alterations in drinking. Instead, hangover measures may be non-causal markers of person-level risk factors that are more directly related to problematic drinking outcomes (e.g., Piasecki, et al., 2012a).

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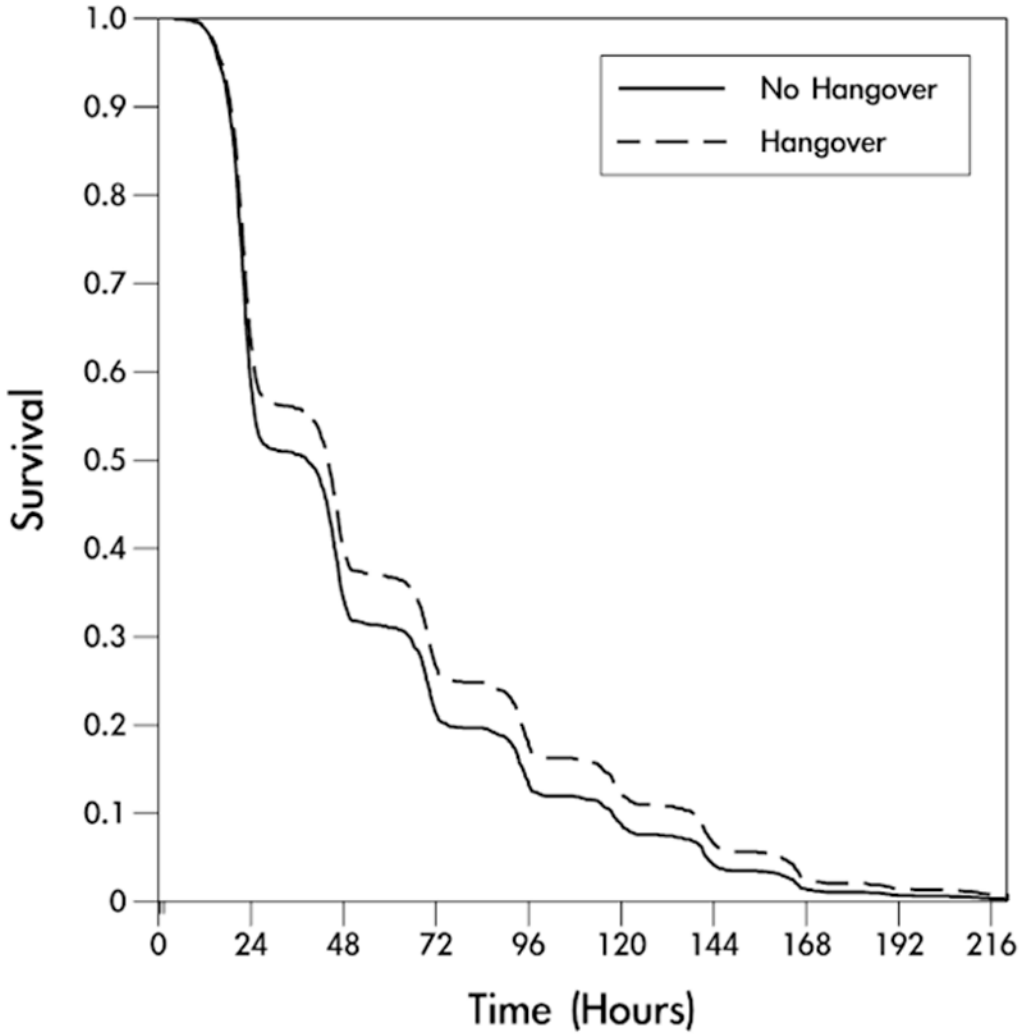

Figure 1.

Survival curves from the model predicting time to next drink with endorsement of hangover after the index drinking episode as the sole predictor.

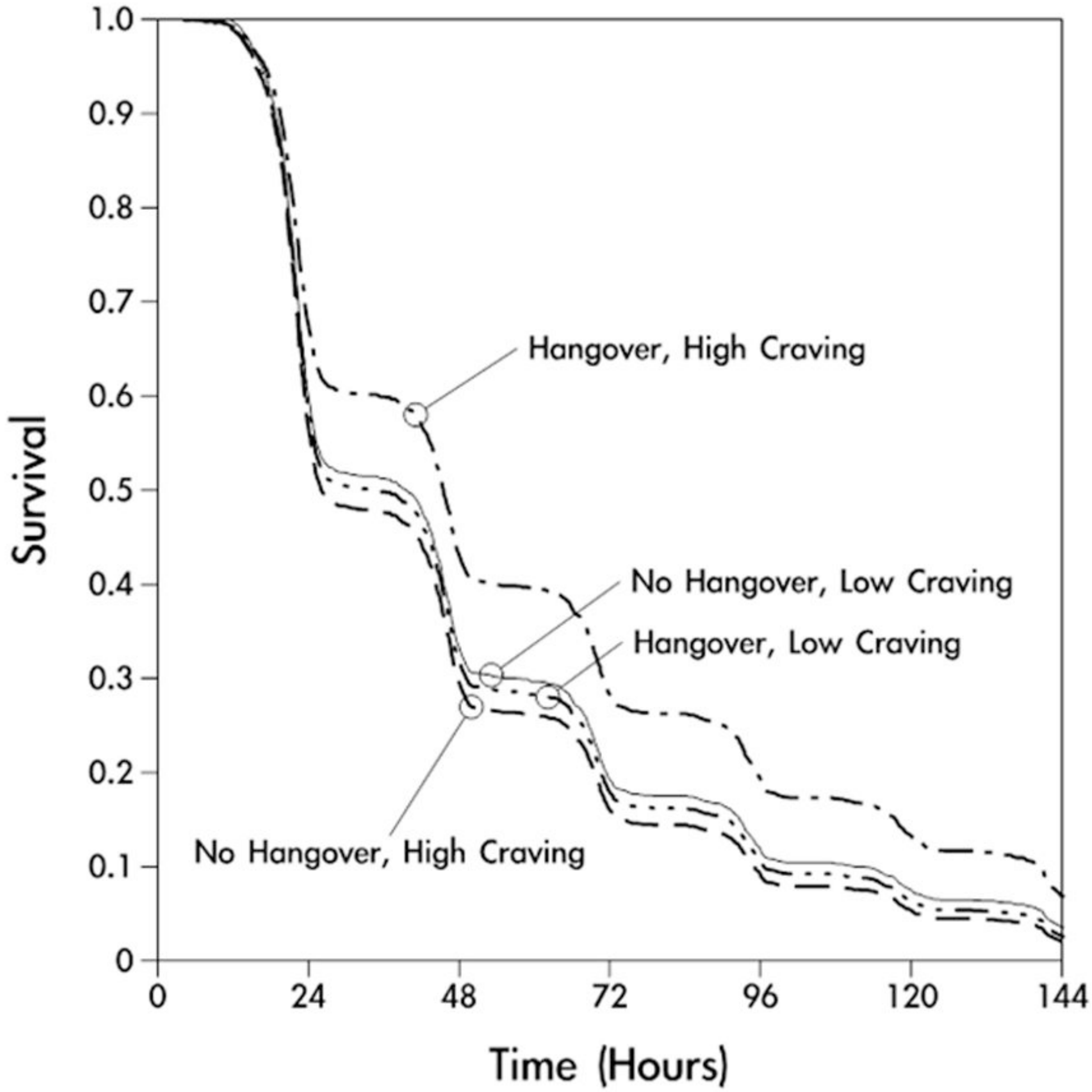

Figure 2.

Survival curves at varying combinations of morning-after hangover status and craving at the end of the preceding drinking episode. The "Low Craving" curves were generated based on a score of 1 ('not at all') on the craving item and the "High Craving" curves were generated based on a craving score of 5 ('extremely'). The curves were produced at the mean of all other covariates in the final multivariate model (Table 3).

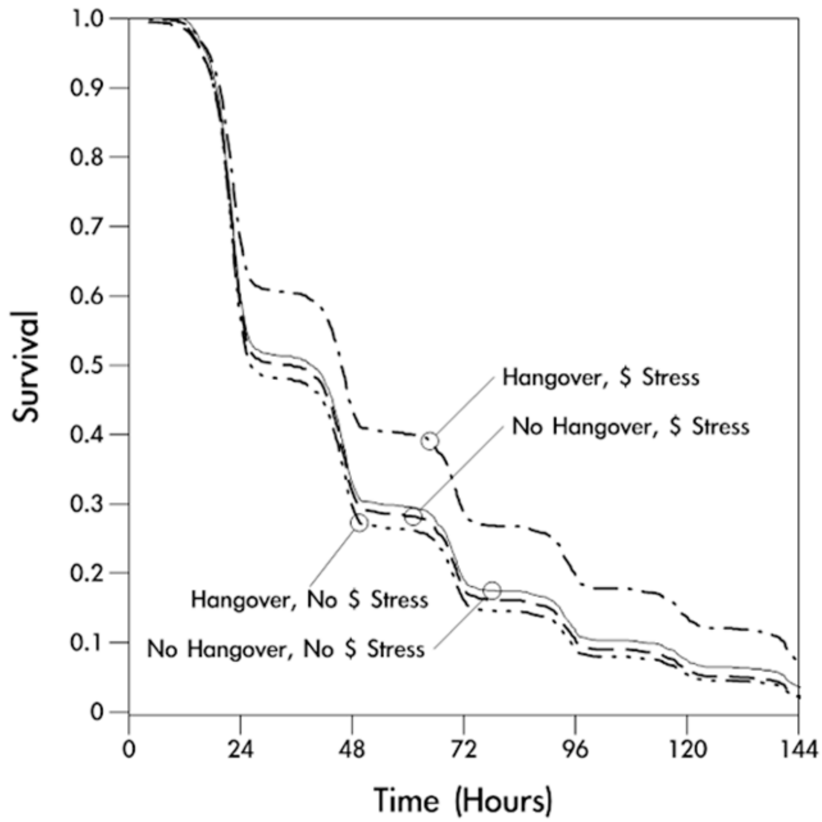

Figure 3.

Survival curves at each possible combination of hangover status and endorsement of financial stressor ($ Stress) at the morning report after the index drinking episode. The curves were produced at the mean of all other covariates in the final multivariate model (Table 3).

Table 1

Sample Characteristics by Hangover Report during the Study.

	Total (n=386)	No Hangover (n=153) N (%)	At Least One Hangover (n=233)
Dichotomous Variables		**N (%)**	
Male	196(50.8)	71 (46.4)	125 (53.7)
White	322 (83.4)	124 (81.1)	198 (85.0)
Never Married***	320 (82.9)	114 (74.5)	206 (88.4)
No Children**	330 (85.5)	122 (79.7)	208 (89.3)
Any Family History	79 (20.5)	33 (21.6)	46 (19.7)
Paternal Family History	65 (16.8)	30 (19.6)	35 (15.0)
Maternal Family History	28 (7.3)	10 (6.5)	18 (7.7)
Smoker Status	247 (64.0)	100 (65.4)	147 (63.1)
Lifetime Alcohol Use Disorder**	127 (33.9)	35 (24.0)	92 (40.2)
Lifetime Drug Use Disorder	34 (9.4)	12 (8.5)	22 (10.0)
Continuous Variables (Range)		M (SD)	
Age (18–70)**	23.48 (7.45)	24.80 (8.65)	22.62 (6.42)
FTND Score (0–8)*	1.36 (2.05)	1.68 (2.02)	1.14 (1.90)
Average Drinking Frequency (0–4)*	3.01 (0.65)	2.92 (0.76)	3.07 (0.57)
Drinking Days During Study (1–21)**	7.90 (4.29)	7.18 (4.56)	8.36 (4.05)
AUDIT Score (2–29)***	12.21 (5.49)	9.58 (4.82)	13.94 (5.21)
Number of Hangovers During Study (0–8)	1.44 (1.65)	-------	2.38 (1.50)
Average Number of Drinks per Episode			
Reported in Real Time (1–26)***	6.55 (4.85)	6.05 (3.62)	7.80 (3.75)
Reported on Morning Report (1–20.5)***	5.62 (4.08)	4.58 (3.16)	7.22 (3.69)
SRE Score (2.3–18.1)***	7.73 (2.87)	7.09 (2.90)	8.15 (2.78)
Drinking Motives			
Coping (0–4)**	1.10 (0.78)	0.96 (0.81)	1.19 (0.75)
Conformity (0–3.6)	0.56 (0.71)	0.51 (0.77)	0.59 (0.67)
Social (0.2–4)***	2.69 (0.91)	2.38 (0.95)	2.89 (0.82)
Enhancement (0–4)***	2.40 (0.92)	2.01 (0.95)	2.66 (0.80)
Barratt Impulsiveness Scale (9–81)*	36.86 (11.32)	35.21 (10.91)	37.96 (11.48)

Note.

* $p < .05$,

** $p < .01$,

*** $p < .001$.

FTND= Fagerstrom Test for Nicotine Dependence. AUDIT = Alcohol Use Disorders Identification Test. SRE = Self-Rating of the Effects of Alcohol scale. Differences between participants with no hangover and those who reported at least one hangover were tested using Chi-Square or Fisher's (when cell sizes were smaller than 5) tests for dichotomous variables and using standard T-tests for continuous variables. In calculating descriptive statistics for FTND scores, nonsmokers were assigned a score of zero. Measures of average number of drinks per episode were computed by first calculating a mean across all episodes contributed by an individual, then taking the average of these person-means.

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Table 2

Results of Univariate Models Predicting Hangover and Time to Next Drink from Person- and Event-Level Measures.

	Outcome Variable	
	Hangover	Time to Next Drink
Predictor Variables	**Odds Ratio**	**Hazard Ratio**
Hangover (Day-level)	-------	0.86*
Likelihood of Drinking Tonight	1.00	1.48***
Person-Level Predictors		
Age	0.96***	1.03***
Male	1.16	1.12
White	1.12	1.08
Never Married	2.66***	0.76**
No Children	1.88**	0.85
Smoker Status	0.70*	1.54***
FTND Score	0.92*	1.06**
Any Family History of Alcohol Problems	0.95	0.97
Paternal Family History	0.76	1.03
Maternal Family History	1.24	0.97
Total number of drinking days in study	0.93***	1.15***
At least one hangover reported	-------	1.12
Number of hangover reported in study	-------	1.05*
AUDIT Score	1.10***	1.02**
Lifetime Alcohol Use Disorder	1.64**	1.34***
Lifetime Drug Use Disorder	1.11	1.22
Typical Drinking Frequency	0.89	1.60***
SRE Score	1.09**	1.01
Drinking Motives		
Coping	1.27*	1.13*
Conformity	1.22	0.91
Social	1.76***	0.91*
Enhancement	1.61***	1.00
Barratt Implusiveness Scale	1.02*	1.00
Day-Level Predictors		
Number of Drinks Reported in Real-Time	1.10***	1.00
Total Drinks Reported on Morning Report	1.31***	0.98**
Number of Cigarettes Smoked	1.07***	1.03***
Length of DE in hours	1.01	1.00

	Outcome Variable	
	Hangover	**Time to Next Drink**
Predictor Variables	**Odds Ratio**	**Hazard Ratio**
Time Morning Report Completed in hours	1.28***	0.96***
Day of Week of DE		
Tuesday	1.06	0.89
Wednesday	1.78*	1.00
Thursday	1.98*	1.44***
Friday	2.75***	1.23***
Saturday	2.51***	0.54***
Sunday	1.21	0.68**
Subjective Measures at End of DE		
Positive Affect (composite)	1.52***	0.95
Negative Affect (composite)	0.88	0.98
Physical Effects (composite)	1.72***	0.97
Craving for Alcohol	1.44***	1.00
Subjective Measures on Morning Report		
Positive Affect (composite)	0.76***	0.98
Negative Affect (composite)	1.27**	0.91**
Physical Effects (composite)	10.60***	0.94
Craving for Alcohol	1.12	1.11*
Work or School Stressor	0.91	1.21***
Financial Stressor	0.94	1.06
Interpersonal or Relationship Stressor	1.19	1.00
Health Stressor	1.01	0.96
Other Stressor	0.78	1.01
Rating of stress since last Morning Report	1.10	0.99

Note.

* $p < .05$,

** $p < .01$,

*** $p < .001$.

FTND= Fagerstrom Test for Nicotine Dependence. AUDIT = Alcohol Use Disorders Identification Test. SRE = Self-Rating of the Effects of Alcohol scale. DE = Drinking Episode. Monday was the reference category for all day-of-the week comparisons. An odds ratio greater than or less than one indicate an increase or decrease, respectively, in the odds of hangover endorsement associated with a one-point increase on the predictor. Hazard ratios greater than one indicate that a one-point increase in the predictor is associated with faster progression to the next drink, while those less than one indicate a one-point increase in the predictor is associated with longer interval between drinking episodes.

Table 3

Results of Final Multivariate Survival Model Predicting Time to Next Drink from Hangover and Selected Covariates.

Predictor Variable	Hazard Ratio	95% CI	*p*-value
Hangover	1.34	0.98, 1.84	.068
Person-Level Predictors			
Age (centered)	1.02	1.01, 1.03	.002
Male	1.10	0.94, 1.28	.254
Smoker	1.11	0.94, 1.28	.227
Typical Drinking Frequency	1.47	1.30, 1.66	<.001
Lifetime AUD Diagnosis	1.19	1.01, 1.40	.042
Coping Motives	1.09	0.98, 1.21	.119
Social Motives	0.94	0.86, 1.03	.208
Day-Level Predictors			
Total Drinks Reported on Morning Report	1.00	0.98, 1.01	.732
Day of Week			
Tuesday	0.87	0.70, 1.08	.208
Wednesday	0.93	0.75, 1.15	.508
Thursday	1.34	1.09, 1.65	.005
Friday	1.22	0.99, 1.50	.057
Saturday	0.57	0.46, 0.70	<.001
Sunday	0.64	0.50, 0.81	<.001
Craving at End of DE	1.00	0.96, 1.05	.861
Work/School Stressor	1.17	1.04, 1.31	.012
Financial Stressor	1.00	0.87, 1.16	.965
Morning Report Negative Affect	0.88	0.82, 0.95	<.001
Morning Report Craving	1.14	1.04, 1.25	.005
Interaction Terms			
Hangover x Craving at End of DE	0.91	0.83, 0.99	.042
Hangover x Financial Stressor	0.68	0.51, 0.90	.008

Note. AUD= Alcohol Use Disorder. DE = Drinking Episode. Monday was the reference category for all day-of-the week comparisons. Hazard ratios greater than one indicate that a one-point increase in the predictor is associated with faster progression to the next drink, while those less than one indicate a one-point increase in the predictor is associated with longer interval between drinking episodes.