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Drinking and Stress: An Examination of Sex and Stressor Differences Using IVR-Based Daily Data

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Abstract

Background—Research on the relation of stress to alcohol consumption is inconsistent regarding the direction of effects, and this association has been shown to vary by sex and type of stress. We sought to build upon the stress-drinking literature by examining the direction of the stress-drinking association over time as well as sex and stressor differences using daily data.

Method—246 heavy drinking adults (67% men) ages 21 to 82 reported daily stress levels and alcohol consumption over 180 days using Interactive Voice Response (IVR). Baseline daily hassles were examined as an alternative measure of stress. Generalized estimating equations (GEEs) were conducted to test the stress-drinking association accounting for alcohol dependency at baseline and sex and stressor type as moderators.

Results—IVR daily stress predicted increased alcohol consumption the following day, whereas baseline level of daily hassles did not. Examining the opposite direction of effects, IVR ratings of daily alcohol consumption predicted decreased next-day stress. Stress predicted higher alcohol consumption the next day for men but there was no significant association for women. For both sexes, drinking predicted decreased stress the next day, but this effect was stronger for women.

Conclusions—This study generally supported the drinking to cope and self-medication hypotheses, with findings that increased stress led to increased drinking. The time-varying relation between stress and alcohol appears to be sex- and measure- specific, however. Therefore, interventions targeted at stress management found to be effective for one sex should not be presumed to be applicable to the other.

Keywords

alcohol; stress; sex differences; interactive voice response

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1. Introduction

Most prominent theories of addiction (e.g., tension reduction, stress-coping, and self-medication) implicate stress as an important trigger for substance use, craving, and relapse (Khantzian, 1985; Koob & Le Moal, 1997; Marlatt & Gordon, 1985; Sher & Levenson, 1982; Shiffman, 1982; Wills & Shiffman, 1985). These theories suggest that drugs and alcohol provide negative reinforcement via relief from stress and positive reinforcement via mood enhancement, both of which lead to increased risk for addiction. Studies testing the theoretical assumption that the direction of causation leads from stress to substance use have produced inconsistent findings (Pohorecky, 1991; Sinha, 2001). Although many studies specifically exploring the relationship between stress and alcohol use have shown evidence that drinking alcohol to cope with stress is related to alcohol abuse and dependence (Armeli, Carney, Tennen, Affleck, & O'Neil, 2000; Cooper, Frone, Russell, & Mudar, 1995; Fox, Bergquist, Hong, & Sinha, 2007), others suggest that alcohol consumption may decrease in response to stress (Van Erp & Miczek, 2001); that stress may rise as a consequence of drinking (Helzer, Badger, Searles, Rose, & Mongeon, 2006); or that stress is unrelated to drinking levels (Fidler & LoLordo, 1996; McCreary & Sadava, 1998). Therefore, further exploration in this area is needed to improve our understanding of the complex relation between stress and alcohol. In this study, we utilized a longitudinal data set tracking daily reports of stress and alcohol use to examine both directions of the relation between drinking and stress, and in particular, whether sex differences moderate this association.

Much of the stress-drinking literature has demonstrated that this association is moderated by sex differences (Fox & Sinha, 2009). For example, women have been shown to drink less alcohol than men in response to stress in several studies examining non-alcohol-dependent women (Armeli, et al., 2000; Nesic & Duka, 2006; Willner, Field, Pitts, & Reeve, 1998). Stress may therefore be a more potent trigger for drinking in men compared to women. Similarly, some have found that alcohol dampens emotional and physiological responding in men but not women (Armeli et al., 2003; Perkins et al., 1995; Udo et al., 2009). That is, the stress response dampening effects of alcohol may be more effective in men. Further, while other investigations have reported significant stress response dampening effects of alcohol in women (Sinha, Robinson, & O'Malley, 1998) or no gender differences in subjective arousal post-alcohol consumption (Schuckit et al., 2000), it has been suggested that these contradictory findings on stress dampening by gender may be due in part to the timing of alcohol consumption. For example, among individuals high in anxiety sensitivity, the stress-dampening effects of alcohol are more effective for men when consumed before a stressor, but after a stressor for women (Zack, Poulos, Aramakis, Khamba, & MacLeod, 2007). This evidence highlights the importance of examining the bidirectional relations between stress and alcohol; rather than focusing on stress as a predictor of alcohol use, the effect of drinking on stress must also be considered.

Further complicating the conceptualization of these processes, there is evidence suggesting that alcohol dependence alters stress reactivity differentially among men and women. For example, alcohol-dependent women report greater emotional distress (e.g., depression, anxiety) in response to stressful stimuli than alcohol-dependent men and social drinkers of both sexes (Fox, et al., 2007; Rubonis et al., 1994). Alcohol-dependent women also have displayed blunted adrenal responsivity after a laboratory-based stress induction compared to alcohol-dependent men (Brady et al., 2006).

Several explanations for sex differences in the relations between stress and alcohol use have been offered (Fox & Sinha, 2009). For example, stressor type could play an important role in determining men and women's stress reactivity. In a sample of 50 healthy volunteers, Stroud, Salovey, and Epel (2002) found that women displayed increased cortisol responses

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to a *social rejection* challenge relative to men, while men showed greater cortisol levels to an *achievement* challenge relative to women. Similarly, the measure and type of stress examined in each study may relate differently to drinking in different samples. McCreary and Sadava (1998) examined perceived stress, daily hassles, and negative life events as predictors of alcohol use and alcohol-related adverse consequences in two samples of young adults. They reported that in their sample of college graduates, none of the measures of stress predicted alcohol use, and only daily hassles predicted alcohol problems. In the community sample, alcohol problems were significantly predicted by negative life events, weakly but significantly predicted by perceived stress, and unrelated to daily hassles. Again, none of these stress measures were associated with alcohol use. This study controlled for sex, but did not report sex differences in relation to these inconsistent stress-drinking associations.

Studies using daily data have offered important contributions to the stress-drinking literature. It can be argued that because daily data are both an in vivo and a concurrent measure of stress and alcohol consumption, the data are more ecologically valid compared to both lab-based experimental studies and retrospective cross-sectional studies (Simpson, Kivlahan, Bush, & McFall, 2005; Tennen, Affleck, Armeli, & Carney, 2000). Daily data have generally supported the notion that stress triggers drinking (Andersson, Gordh Soderpalm, & Bergllund, 2007; Armeli, et al., 2000; Grzywacz & Almeida, 2008; Park, Armeli, & Tennen, 2004). However, the reported sex differences in this body of research have been inconsistent. For example, Carney and colleagues (2000) reported that women had more desire to drink than men on days they experienced non-work (e.g., financial, social) related negative events. In the same sample, Armeli et al. (2000) found that men and women both reported stronger desires to drink on stressful days. These findings were based on within-day associations, however, and thus direction of effect cannot be determined. In a sample of 32 women, Breslin and colleagues (1995) showed that subjects drank less alcohol during weeks when their mean daily stress level was in the upper versus the lower tercile. Schroder and Perrine (2007) identified “stress drinking” as one of four distinct clusters of drinking types but failed to identify sex differences within clusters.

Although daily data collection provides a more naturalistic observation of stress-drinking associations over time, there are methodological limitations in the existing research that may explain some of its inconsistencies. First, the length of time over which subjects were assessed has ranged from seven days (Andersson, et al., 2007) to two years (Helzer, et al., 2006; Schroder & Perrine, 2007). Increasingly extended time periods might produce more reliable within-person data on stress and drinking relative to shorter studies. In addition, sample size has varied, from 15 (Andersson, et al., 2007) to 802 (Grzywacz & Almeida, 2008). Sex distribution (i.e., proportion of men and women) is also inconsistent, with some studies focusing on women only (Breslin, O’Keeffe, Burrell, Ratliff-Crain, & Baum, 1995), some on men (Helzer, et al., 2006; Rohsenow, Smith, & Johnson, 1985), and others with varying proportions of men and women (Armeli, et al., 2003; Flynn, 2000; Steptoe & Wardle, 1999). Importantly, many of these samples excluded alcohol-dependent participants (Armeli, Dehart, Tennen, Todd, & Affleck, 2007; Carney, Armeli, Tennen, Affleck, & O’Neil, 2000), or did not assess dependency (Andersson, et al., 2007; Grzywacz & Almeida, 2008). Alcohol dependency has been shown to differentially affect stress reactivity in men and women (Fox, et al., 2007), and yet has not, to our knowledge, been accounted for in any of the investigations using daily data. Furthermore, while previous literature has demonstrated that variations in stressor type and measurement lead to divergent findings for men and women, and for drinking (McCreary & Sadava, 1998; Stroud, Salovey, & Epel, 2002), this has not been examined via daily data to date. The daily data literature has also focused primarily on within-day stress-drinking associations (Armeli, et al., 2003; Park, et al., 2004), and very infrequently on stress and next day drinking (Andersson, et al., 2007), or

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on drinking and next day stress (Armeli, et al., 2003). The direction of the stress-drinking association for men and women is therefore not yet clear.

Overall, conclusions about the effects of stress on alcohol consumption (and vice versa) are based on laboratory experiments in which alcohol is administered and there is a measureable blood alcohol level (Fox & Sinha, 2009). The focus of this study, however, is on the relations between stress and drinking across a 24-hour period. Presumably, high levels of stress and/or drinking occurring one day will have dissipated to some extent by the following day. That is, alcohol consumed today will have been metabolized 24 hours later, and stress levels are also likely to have changed (decreased or increased) within a 24 hour period. Thus, the effect of drinking today on stress tomorrow may be weaker than the effect of drinking on stress measured within a relatively short time frame as in laboratory studies. Similarly, today's stress may less powerfully predict number of drinks consumed tomorrow as compared to drinks consumed immediately following or during a stressor (i.e., as in many laboratory-based studies).

In sum, prominent theories and some empirical work have suggested that stress triggers alcohol consumption, which then dampens stress responding. However, experimental and longitudinal literatures have revealed that this is not always the case, particularly when alcohol dependency, stressor type, and sex differences are directly examined. Research using daily reports of stress and drinking has revealed patterns of the stress and drinking association over time, but has primarily focused on within-day associations from which conclusions about direction of effect cannot be made. In addition, sex differences have generally not been directly examined in these studies. In the study reported herein, we sought to build upon the extant stress-drinking literature by using 6 months of daily data to examine sex differences in the stress-drinking association. We examined two different measures of stress (i.e., daily stress ratings & baseline assessment of daily hassles), and accounted for alcohol dependency in a mixed-gender sample. We began with the following hypotheses:

1. Although previous literature has found that stress predicts drinking in the lab or within one day, stress will not significantly predict total number of drinks reported the next day;
2. After controlling for alcohol dependency, stress will predict next day drinking for men more strongly than for women, consistent with findings within non-alcohol-dependent samples (Armeli et al., 2000; Nesic and Duka, 2006; Willner et al., 1998);
3. Increased alcohol consumption will result in no significant change in stress levels the following day for women or men.

For each of these associations, we examined whether measure of stress (i.e., a baseline measurement of hassles vs. daily subjective stress ratings) changes the nature of the relation between stress and drinking. To the best of our knowledge, this is the first longitudinal investigation examining two types of stress in relation to drinking and accounting for the potential moderating effects of sex.

2. Methods

Data for the current manuscript were obtained from a trial of Interactive Voice Response (IVR) as a treatment adjunct to brief intervention in primary care. The purpose of the trial was to determine if self-monitoring of alcohol use and associated variables via IVR in the six months following brief intervention would produce better outcomes than no self-monitoring after brief intervention. Three experimental conditions were compared: no IVR,

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IVR only, or IVR plus feedback, wherein participants were given monthly feedback on the drinking data they provided to the IVR. The detailed design of this study is provided in Helzer, et al. (2008); pertinent details of the methods are briefly summarized here.

2.1 Participants

Participants were recruited from April 2000 to July 2003 from 15 primary care offices in the Burlington, VT metropolitan area. During the study recruitment period, providers were encouraged to screen their patients for heavy alcohol use and were trained to conduct brief alcohol interventions (BI) when appropriate. Patients who received a BI and were willing to consider further intervention in a randomized trial were referred to the study team. Criteria for study inclusion were based on recent (3-month) history of alcohol consumption that exceeded either of the National Institute on Alcohol Abuse and Alcoholism (NIAAA) limits for low-risk drinking, i.e., (1) average daily or weekly drinking of no more than 2 per day/14 per week for men or 1 per day/7 per week for women, or (2) daily maximums of 5 for men or 4 for women. Exclusion criteria included: 1) current (1-year) DSM-IV diagnosis of substance dependence other than alcohol, nicotine, or marijuana; and 2) current (1-year) DSM-IV diagnosis of psychosis, or of major depression with recent initiation or change in antidepressant medication.

2.2 Demographics of sample

The sample under analysis consists of subjects in Helzer et al.'s (2008) two IVR conditions. There were 246 adults (166 men, 80 women) with a mean age of 45.72 years (SD=12.79, range=21–82). Of the 246 participants, approximately 97% were Caucasian-non Hispanic. The mean years of education for this sample was 14.87 (SD=2.86, range=5–24) and 76% of the sample reported being employed full time.

2.3 Apparatus

This study employed Interactive Voice Response (IVR), a computer-driven telephone system that was accessible 24 hours a day through a toll-free number. The IVR was programmed to administer a 2-minute daily questionnaire to which participants could respond using the touchtone telephone keypad. The questionnaire items included daily alcohol consumption, stress, mood, health, and relationship with partners. Questions were all focused on the previous 24 hours so as to ensure a consistent reporting period.

2.4. Procedure

Research personnel contacted each referral by telephone to briefly explain the study and invite them to participate. Participants were scheduled for an in-person consent and evaluation at our research office. The full assessment battery is reported in Helzer, et al. (2008).

After the evaluation, participants in the IVR condition received a 20-minute training session in the use of the IVR system, including instruction for how to report alcohol consumption according to standard drink amounts. Participants were asked if they had a goal for the maximum drinks they would have in a day. Participants were asked to call once each day to complete the IVR survey. In the first month, any patient who missed two successive IVR reports received a reminder call by a staff member. After the first month, no reminder calls were given. Participants in the IVR plus feedback condition were mailed a graph at the end of each month that displayed the number of drinks the participant had reported on each of the preceding 30 days. The graph included a horizontal line representing the drinking goal the participant had stated at intake. The mailing also included a brief personal note from Dr. Helzer that offered encouragement and congratulations for success.

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2.4.1 Outcome and Predictor Variables—In this report, we focused on two time-varying outcome variables that were assessed on the IVR daily questionnaire: maximum stress and total number of drinks. Predictor variables were day of the week (Sunday as reference category), sex, total hassles (assessed at baseline), and alcohol dependency (also assessed at baseline). For models including stress as an outcome, total number of drinks was included as a predictor. For models where total drinks was the outcome, stress was included in the model as a predictor.

2.4.2 IVR Variables—Stress was assessed with the following item: **"**Rate your highest level of stress yesterday on a scale of 0 to 9 with 0 being no stress and 9 being the highest stress you've ever experienced." Over the entire study period, the mean stress reported was 3.2 with a standard deviation of 2.3. Our variable measuring total drinks was a sum of the number of beers, drinks containing liquor, and glasses of wine the individual consumed. To determine these amounts, participants were asked how many drinks of each type of alcohol they consumed the previous day. The sum measure had a possible range of 0 to 40 with a mean of 3.8 and a standard deviation of 3.8 across the entire study period.

2.4.3 Baseline Total Hassles—Total hassles was assessed at the initial in-person evaluation using the Hassles and Uplifts Combined scale (Lazarus & Folkman, 1989), a self-report measure including 53 items on which participants rated the extent to which each item (e.g., "the nature of your work") is a hassle or uplift. Hassles and uplifts were rated on a 4-point scale ranging from 0 to 3, where 0 is "none or not applicable," and 3 is "a great deal." The total hassles variable is a sum of the hassles ratings across all 53 items. In this sample, total hassles scores ranged from 0 to 129 with a mean of 42.26 (SD = 18.55) at baseline.

2.4.4 Alcohol Dependency—Alcohol dependency was assessed using the Composite International Diagnostic Interview – Substance Abuse Module (CIDI_SAM; (Cottler, Robins, & Helzer, 1989) with 66% of the sample meeting criteria for a binary designation of alcohol dependent at baseline.

2.5. Statistical Analyses

Descriptive and regression statistical analyses were conducted in STATA 9.2 (StataCorp, 2005) utilizing the longitudinal data environment, clustering by unique identification number (ID) and sorting by treatment day (TIME) consecutively from 1 –180. STATA uses listwise deletion for cases with missing data. Associations between repeated outcomes and predictors were modeled using the STATA command to fit population-averaged, general linear, models (generalized estimating equations, GEE (Hardin & Hilbe, 2003)) allowing for a user-defined within-ID correlation structure. We explored several potential within-ID correlations (exchangeable, independent, unstructured or auto-regressive) and determined an exchangeable correlation structure fit the data best, and therefore, all GEE models assumed an exchangeable correlations structure.

Simple regressions using GEE between predictors and outcomes were followed by GEE models controlling for all predictor variables as observed confounders. The previous day's value of the other outcome variable was the main predictor of interest in these models (for example, previous day total drinks as a predictor of stress). Following these models, we explored the potential moderating effects of sex with our main variables of interest. First we explored the interaction between sex and previous day stress predicting total drinks, followed by sex interacting with previous day total drinks predicting stress. Our other main research question was whether sex moderated the effect of baseline total hassles on total drinks, so we looked at the interaction between sex and total hassles predicting total drinks

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controlling for previous day stress. Significant interaction terms were explored further by stratifying the model by sex.

3. Results

3.1 Exploratory Analyses

Looking first at simple associations with our daily stress outcome, higher baseline average total hassles score as well as baseline alcohol dependency significantly predicted higher average daily stress (b[1]=.03, p=.000 and b=.77, p=.001, respectively). Being male was associated with lower average daily stress (b=−.63, p=.007) as was previous day total number of reported drinks (b=−.03, p=.000). Finally, day of the week was also a significant predictor of stress. In comparison to Sunday, significantly higher stress levels were reported Monday through Friday (b range=.57 – .60, ps=.000), while there was no difference between Saturday and Sunday stress levels (b=.03, p=.377).

Next, we explored the simple associations between our predictors and our other outcome of interest: total drinks. Interestingly, baseline alcohol dependency and baseline average total hassles score did not significantly predict average number of daily reported total drinks (b=.67, p=.073, and b=−.01, p=.242, respectively), but male sex did predict a higher average number of daily reported total drinks (b=1.0, p=.008). Surprisingly, we found a positive relation between previous day's stress and average number of daily reported total drinks (b=.04, p=.000). Finally, simple tests between day of the week and total number of drinks revealed that more total drinks were reported on Friday (b=.29, p=.000) and Saturday (b=.60, p=.000) than Sunday. Fewer total drinks were reported Monday through Thursday (b range=−.89 – −.48, ps=.000) compared to Sunday.

3.2 Main Effects in Overall Sample

For the main GEE analyses, alcohol dependency and day of the week, with Sunday as the reference category, were included as confounders given their theoretical and statistical relevance to the current investigation. Age was also initially included in these models as a potential confounder of the association between stress and drinking. However, age did not alter the regression coefficients, standard errors, significance levels, or confidence intervals of our primary predictors (i.e., stress and total drinks) at the precision level that we are reporting and thus was removed from these models. We found that stress was significantly associated with next day total drinks controlling for the effects of alcohol dependency and day of the week (Table 1). For every one-unit increase in the ten-point stress scale, participants reported drinking .02 more drinks the next day (p<.001) on average. Interestingly, baseline total hassles score did not significantly predict total drinks (Table 1).

Turning our focus to the effects of total number of daily drinks predicting average stress controlling for day of the week and alcohol dependency, the relation between drinking and next day stress was in the negative direction, indicating that for each additional drink, participants reported a .01-unit decrease in stress the next day (p<.001; Table 2).

3.3 Sex Differences

We found that sex significantly moderated the association between stress and next day drinking (p<.001; Table 3) so this interaction was further explored by examining the relation between stress and next day drinking within each sex separately. These analyses revealed that there was a mean increase of .04 drinks (p=.001) for each one-unit increase in stress the

[1]Note: here and throughout the remainder of this paper, b denotes the unstandardized regression coefficient.

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previous day for men, yet there was no significant change in drinking following stressful days for women (Table 3).

Similarly, the interaction between total drinks and sex significantly predicted next day stress (Table 4). In analyses stratified by sex, greater drinking was related to decreased stress the following day, but this effect was stronger for women than men. Specifically, women reported a .03-unit decrease in stress for each additional drink consumed the previous day ($p<.01$), whereas men reported only a .01-unit decrease in stress for each additional drink consumed the previous day ($p<.05$).

Finally, examining the interaction between baseline total hassles and sex, results differed from those found with regard to stress. Specifically, the interaction between baseline total hassles and sex was not significantly related to total drinks after accounting for daily stress ($p=.080$).

4. Discussion

Stress has been hypothesized to be a major predictor of and trigger for alcohol use (Khantzian, 1985; Marlatt & Gordon, 1985; Shiffman, 1982; Wills & Shiffman, 1985). The relation between stress and alcohol use is complicated, however, by factors such as the definition of stress, the measurement tools, the timing and frequency of measurement, gender issues, and how alcohol dependency is handled (Fox & Sinha, 2009; Stroud, et al., 2002). The majority of studies in this area have used lab-based experimental or cross-sectional designs, which limit the generalizability of findings as well as understanding of the association between stress and alcohol over time. In this study, we sought to further explore the relations between stress, drinking, and sex using 180 days of daily data. We were able to test the effect of stress on drinking - and vice versa - the following day. In addition, we tested whether these associations differed when an individual's baseline ratings of daily hassles were used as an alternative measure of stress, and examined how stress and drinking were differentially related for men and women over the course of the 180 days. For each tested model, we were able to account for alcohol dependency status, which has been implicated as a modifier of stress reactivity (Fox & Sinha, 2009).

Contrary to our hypothesis, stress predicted drinking the next day, suggesting that stress may be more than just an immediate trigger for drinking. Consistent with some previous research (McCreary & Sadava, 1998), there was no significant effect of baseline total hassles on drinking above and beyond the effect of self-reported previous day stress. This implies that, with regard to daily alcohol consumption, the effect of prior multiple stressors/hassles may be less of an influence than an individual's proximal subjective experience of stress. Therefore, measuring stress levels during and immediately preceding a day of drinking is most important in understanding part of the relation between stress and alcohol use.

Examination of total drinks as a predictor of stress also yielded somewhat unexpected results. Specifically, more drinking was predictive of *less* stress the following day. This implies that alleviation of stress provided by drinking - that is, negative reinforcement - appears to last beyond the period of initial intoxication. An individual's affect also may play an important role in whether drinking helps to alleviate negative affect/stress or to enhance mood and physiological sensation (Cooper, et al., 1995). While this study has helped to shed light on the complex bi-directional relations between stress and drinking at the daily level, future studies should explore the role of individuals' affect and expectations of how their drinking will simultaneously increase positive emotion/sensation, for example by examining "uplifts" (e.g., from the Hassles and Uplifts questionnaire used here).

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One major exploration conducted in this study was to determine what role sex played in moderating the stress-drinking relationship in both directions. Consistent with hypotheses, stress predicted a higher number of drinks the following day for men than women. Therefore, there may be a delay in men's decisions to drink in response to stress, or that alternative coping skills are not perceived as immediately effective for men. It is possible, for example, that non-alcohol related coping skills are first employed to manage stress, but after reaching some threshold of stress tolerance, the individual decides to drink with hopes of gaining relief more quickly. Additional research is needed to determine (1) whether this explanation is valid, and (2) why it would be male-specific.

When drinking was examined as a predictor of stress relief, women showed a greater decrease in stress the next day relative to men. Therefore, it is even more interesting that despite this reinforcing effect of alcohol for women, we found that they did not report drinking significantly more alcohol in response to stress. Additional research can help determine whether this finding is due to overall differences in alcohol metabolism between the sexes (Frezza et al., 1990), requiring higher amounts of alcohol to achieve intoxication for men. Alternatively, there may be sex differences in the social acceptability of heavy drinking or alcohol outcome expectancies as they relate to drinking behavior (Abrams & Kushner, 2004) which influence these findings.

Research on sex differences in the reporting of stress has evidenced that men and women describe and experience emotions differently (Fischer, Rodriguez Mosquera, van Vianen, & Manstead, 2004), so while stress may elicit an urge to drink for men, there may be specific emotions (e.g., sadness) that are more powerful predictors of drinking for women (Chaplin, Hong, Bergquist, & Sinha, 2008). In addition, women may have a higher threshold after which stress leads to drinking. Indeed, there is a higher prevalence of anxiety and depression in female compared to male alcohol abusers in the general population (Kessler et al., 1997), which may suggest that women are more likely to drink once they reach clinically significant levels of distress manifested as anxiety and depression, whereas lower stress levels can be triggers for drinking among men. Therefore, more specific definitions of stress should be used in future research to better understand how stress levels and negative emotions differentially impact drinking behavior for men and women.

In this study, we attempted to shed light on the question of how definition or type of stress relates to drinking for each sex by examining daily hassles as an alternative measure of stress. While there were sex-specific findings for the relations between self-reported IVR stress and alcohol consumption, sex did not moderate the relation between hassles and drinking in this study. It is possible that examination of specific types of hassles (e.g., work, family, social, financial) would reveal sex-specific effects that were not evident in this study due to the use of an overall measure of daily hassles. Future studies may provide better insight into the role of daily, chronic stressors on drinking within each sex using this approach. Moreover, we used a baseline measure of hassles, which may not have accurately captured hassles, or change in hassles, throughout the course of the study. In the future, *change* in hassles should be considered as a predictor of drinking. That is, a dramatic increase or decrease in daily hassles at a point in one's life may be what triggers increased or decreased drinking for certain individuals.

The current study was the first to our knowledge to examine sex differences in stress and drinking between days and longitudinally. IVR technology allowed us to measure such patterns naturalistically and prospectively over the course of six months. Further, we were able to investigate the role of two different types of stress ratings: (1) a general one-time measure of daily hassles, and (2) a daily, single-item indicator of stress. In addition, alcohol

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dependency was modeled in all analyses in order to account for its role in stress reactivity and drinking patterns.

This study is limited, however, in a number of ways. First, the sample included a high proportion of individuals who were alcohol dependent or heavy drinkers and all had received a brief intervention from his or her doctor. Therefore, the findings reported here may not be generalizable to moderate drinkers or those who drink infrequently. Second, all included variables were based on self-report via interviews or questionnaires. While it was not feasible to collect daily drinking data via biological indicators (e.g., breathalyzer) for the purposes of this study, incorporation of such techniques within future multi-method investigations might help to validate and expand upon this literature. Furthermore, it is likely that other variables not measured or explored further in this study play a significant role in the relations between stress and drinking (e.g., personality, coping styles, alcohol outcome expectancies, family history of alcohol dependence). Examination of these and other theoretically confounding variables in future studies using daily data can help to further tease apart the relations between stress and drinking, and to better understand the etiology and treatment of alcohol dependence. Finally, the effects reported here can be interpreted as relatively small. For example, every one-unit increase on the ten-point stress scale was predictive of a .02 drink increase the following day in the overall sample and a .04 drink increase the following day for men. However, such seemingly minor relationships may become relevant if the effect accumulates over time because the progression from first drink to alcohol dependence is thought to be a multi-stage process typically occurring over a number of years (Langenbucher & Chung, 1995; Sartor, Agrawal, Lynskey, Bucholz, & Heath, 2008). It is therefore possible that persistent, relatively minor increases in drinking due to stress like those shown here eventually culminate in alcohol dependency. Prospective research testing this hypothesis is needed to better evaluate the clinical significance of our results. Finally, our study assessed stress and drinking once per day, and it is thus not possible to determine which occurred first within a given day.

This study generally supported the drinking to cope and self-medication hypotheses, with findings that increased stress led to increased drinking. However, exploration of sex differences revealed that this association was specific to men, and that women did not report drinking in response to stress. For both sexes, and particularly for women, drinking did appear to alleviate stress the following day, suggesting that the reinforcing effects of drinking apply to both sexes and supporting the proposed stress-dampening and self-medication effects of alcohol. This study highlights the need for both clinical interventions and research to take sex into consideration when examining the relation between stress and drinking. The mechanisms and extent to which stress and drinking relate are sex-specific, and therefore interventions targeted at stress management found to be effective for one sex should not be presumed to be applicable to the other.

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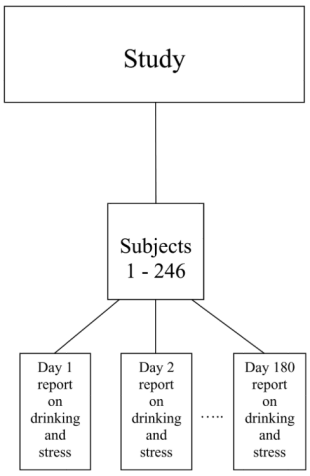

Figure 1.
Graphical representation of longitudinal study design

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Table 1

Main Effects of Stress and Total Hassles on Next Day Total Drinks

		DV: Next Day Total Drinks			
Primary Predictor: Stress		**b**	**SE**	**p**	**95% CI (low, high)**
Time since beginning of study		−.005	.0003	.000	−.01, −.004
Day of the Week*	Monday	−.86	.06	.000	−.97, −.74
	Tuesday	−.80	.06	.000	−.92, −.68
	Wednesday	−.55	.06	.000	−.67, −.44
	Thursday	−.47	.06	.000	−.59, −.35
	Friday	.31	.06	.000	.19, .43
	Saturday	.61	.06	.000	.49, .73
Alcohol Dependency (yes/no)		.63	.38	.096	−.11, 1.4
Stress score		**.02**	**.01**	**.042**	**.001, .04**
Primary Predictor: Total Hassles		**b**	**SE**	**p**	**95% CI (low, high)**
Time since beginning of study		−.01	.0003	.000	−.01, −.004
Day of the Week*	Monday	−.91	.06	.000	−1.0, −.79
	Tuesday	−.85	.06	.000	−.97, −.73
	Wednesday	−.57	.06	.000	−.70, −.46
	Thursday	−.50	.06	.000	−.61, −.38
	Friday	.26	.06	.000	.15, .38
	Saturday	.61	.06	.000	.50, .73
Alcohol Dependency (yes/no)		.75	.39	.056	−.02, 1.5
Stress score		.04	.01	.000	.02, .06
Total Hassles		**−.02**	**.01**	**.096**	**−.04, .003**

*Sunday is reference day

Note. DV: Dependent Variable; b: regression coefficient; SE: Standard Error; p: p-value; CI: Confidence Interval; ns: not significant.

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Table 2

Main Effects of Total Drinks on Next Day Stress

		DV: Next Day Stress			
		b	**SE**	**p**	**95% CI (low, high)**
Time since beginning of study		−.002	.0002	.000	−.003, −.002
Day of the Week*	Monday	.56	.04	.000	.49, .64
	Tuesday	.67	.04	.000	.60, .75
	Wednesday	.63	.04	.000	.56, .71
	Thursday	.61	.04	.000	.53, .68
	Friday	.59	.04	.000	.52, .67
	Saturday	.03	.04	.360	−.04, .11
Alcohol Dependency (yes/no)		.72	.23	.002	.27, 1.2
Total Drinks		**−.01**	**.004**	**.000**	**−.02, −.01**

*Sunday is reference day

Note. DV: Dependent Variable; b: regression coefficient; SE: Standard Error; p: p-value; CI: Confidence Interval; ns: not significant.

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Table 3

Interaction Effects of Sex* Stress on Next Day Total Drinks

		DV: Next Day Total Drinks			
		b	**SE**	**p**	**95% CI (low, high)**
Time since beginning of study		−.005	.0003	.000	−.01, −.004
Day of the Week*	Monday	−.86	.06	.000	−.98, −.74
	Tuesday	−.81	.06	.000	−.92, −.69
	Wednesday	−.56	.06	.000	−.68, −.44
	Thursday	−.47	.06	.000	−.59, −.36
	Friday	.30	.06	.000	.19, .42
	Saturday	.61	.06	.000	.49, .73
Alcohol Dependency (yes/no)		.63	.37	.086	−.09, 1.4
Stress score		−.02	.02	.128	−.06, .01
Sex		.97	.37	.009	.24, 1.7
Stress* Sex		**.07**	**.02**	**.000**	**.03, .10**

*Sunday is reference day

Note. DV: Dependent Variable; b: regression coefficient; SE: Standard Error; p: p-value; CI: Confidence Interval; ns: not significant.

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Table 4

Interaction Effects of Sex* Total Drinks on Next Day Stress

		DV: Next Day Stress			
		b	**SE**	**p**	**95% CI (low, high)**
Time since beginning of study		−.002	.0002	.000	−.003, −.002
Day of the Week*	Monday	.56	.04	.000	.49, .64
	Tuesday	.67	.04	.000	.60, .74
	Wednesday	.63	.04	.000	.55, .70
	Thursday	.61	.04	.000	.53, .68
	Friday	.59	.04	.000	.52, .67
	Saturday	.03	.04	.359	−.04, .11
Alcohol Dependency (yes/no)		.72	.22	.001	.28, 1.2
Total Drinks		−.03	.01	.001	−.05, −.01
Sex		−.71	.23	.002	−1.2, −.26
Total Drinks* Sex		**.02**	**.01**	**.033**	**.002, .04**

*Sunday is reference day

Note. DV: Dependent Variable; b: regression coefficient; SE: Standard Error; p: p-value; CI: Confidence Interval; ns: not significant.