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An Event-Level Examination of Sex Differences and Subjective Intoxication in Alcohol-Related Aggression

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Abstract

Laboratory-based experimental research has demonstrated that the pharmacological effects of alcohol can increase aggressive responding. Given mixed findings and concerns regarding task validity, however, it remains uncertain whether this effect holds constant across men and women and whether variability in subjective alcohol intoxication contributes to alcohol-related aggression. In the present investigation, we used four years of event-level data in a sample of 1,775 college students (140,618 total observations) to provide a test of laboratory-derived findings on the link between alcohol and aggression in an alternative methodology. We found support for several such findings: 1) Within-person increases in alcohol intoxication, as assessed by estimated blood alcohol concentrations (eBACs), were associated with increases in the probability of aggression at the drinking-episode level; 2) This association was significantly stronger among men than among women; and 3) Within-person variability and between-persons individual differences in levels of subjective alcohol intoxication were associated with aggression over and beyond eBACs. Cross-methodological replication can reduce the impact of constraints specific to experimental studies on conclusions regarding alcohol's relation with aggression.

Keywords

Aggression; Alcohol Use; Event-Level; Sex Differences; Subjective Intoxication

Laboratory-based research has been the primary methodology used to examine alcohol's acute effects on aggression, and results of these investigations have consistently demonstrated that alcohol intoxication can increase aggressive responding (for reviews, see Bushman & Cooper, 1990; Chermack & Giancola, 1997; Giancola, Josephs, Parrott, & Duke, 2010). Findings have been inconsistent, however, with respect to women's alcohol-related aggression and the possible role of subjective intoxication. The current study sought to test whether the prevailing findings from laboratory-based studies of alcohol-related aggression could be replicated using an event-level methodology. Specifically, our goals were to examine the moderating role of biological sex and the possible contribution of subjective intoxication to alcohol-related aggression in the natural environment.

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Aggression in the laboratory is typically assessed using behavioral tasks in which participants compete against a fictitious opponent (reviewed in Giancola & Chermack, 1998). These experimental methodologies have been used to examine the influence of factors including sex, acute alcohol intoxication, alcohol expectancies, dispositional aggression, and subjective intoxication on alcohol-related aggression (e.g., Giancola, 2002a, 2002b, 2002c; Giancola, Godlaski, & Parrott, 2005; Giancola & Zeichner, 1995; Gussler-Berkhardt & Giancola, 2005; Parrott & Zeichner, 2002; Phillips & Giancola, 2008). After several decades of laboratory research in this area, it has become clear not only that alcohol intoxication increases aggressive behavior but also that the effects of alcohol on aggression vary across individuals.

Notably, sex differences in the link between alcohol and aggression have emerged. Whereas laboratory findings on the influence of intoxication on aggression have been robust for men, evidence for an alcohol-aggression link for women is mixed (Bond & Lader, 1986; Dougherty, Bjork, Bennett, & Moeller, 1999; Dougherty, Cherek, & Bennett, 1996; Giancola et al., 2002; Giancola & Zeichner, 1995; Gussler-Burkhardt & Giancola, 2005; Hoaken, Campbell, Stewart, & Pihl, 2003; Hoaken & Pihl, 2000). Laboratory studies have most typically concluded that alcohol has no effect on aggression among women (Giancola, 2006; Giancola et al., 2002; Giancola & Zeichner, 1995; Gussler-Burkhardt & Giancola, 2005; Hoaken & Pihl, 2000) or that the effect is weaker among women relative to men (Giancola et al., 2009), although a few studies have found that alcohol increased aggression similarly among women and men (Dougherty et al., 1999; Duke, Giancola, Morris, Holt, & Gunn, 2011).

These findings have been interpreted by some to suggest that alcohol's effects may be stronger among men relative to women. Others, however, have raised questions regarding the construct validity of the laboratory aggression paradigms used in these studies. The experimental procedure used by many of the studies cited above (i.e., the Taylor Aggression Paradigm [TAP]; Taylor, 1967) involves the administration of electric shocks to a fictitious opponent. In addition to general concerns about whether the TAP accurately reflects aggressive behavior, questions about the validity of the TAP among women have challenged conclusions regarding sex differences in alcohol-related aggression (Tedeschi & Quigley, 1996). Giancola and Parrott (2008), for example, found that TAP performance was more strongly associated with self-reported aggression among men relative to women. Although the authors concluded that this moderation effect supported the validity of the task, an alternative interpretation is that performance on the TAP is less representative of aggressive behavior among women.

It is noteworthy, moreover, that although we are aware of few studies using the TAP in which alcohol increased aggression similarly for men and women (but see Duke et al., 2011 for a recent counter-example), several studies using different procedures to assess aggression, including subtracting points redeemable for money (i.e., the Point Subtraction Aggression Paradigm) and articulating aggression intentions in response to a hypothetical interpersonal conflict (i.e., Articulated Thoughts in Simulated Situations), found similar alcohol-induced aggression in men and women (Dougherty et al., 1999; Eckhardt & Crane, 2008). Discrepancies in women's aggression across studies using different experimental procedures may therefore reflect a sex bias in the procedures rather than a true difference in alcohol-influenced aggression. Replication using alternative methodologies could help resolve this question.

In addition to sex, subjective intoxication is another factor that may contribute to individual differences in alcohol's effects on aggression. Individuals vary in the degree to which they respond to alcohol, even at similar levels of objective intoxication (as represented by breath

or blood alcohol concentrations), which may be a function of family background or personal drinking history (Morean & Corbin, 2010; Quinn & Fromme, 2011b; Ray, MacKillop, & Monti, 2010). Although most laboratory alcohol-aggression studies have focused exclusively on the effects of objective intoxication, two studies that also tested the role of subjective intoxication have yielded mixed results (Giancola, 2006; Giancola & Zeichner, 1995). In one, objective but not subjective intoxication predicted men's aggressive responding (Giancola, 2006). In the other, both objective and subjective intoxication predicted aggression among men exposed to high provocation (Giancola & Zeichner, 1995). The role of subjective intoxication in alcohol-related aggression therefore remains unclear and under-investigated.

Alcohol and Aggression in the Natural Environment

Although there are many advantages to laboratory-based research, discrepant findings across studies and experimental procedures highlight the importance of examining evidence from different methodologies (as suggested by Tedeschi & Quigley, 1996). Similar to laboratory investigations, event-level and observational studies can examine the link between acute alcohol intoxication and aggression, and they have provided consistent evidence that alcohol intoxication is positively related to aggression (e.g., Collins, Quigley, & Leonard, 2007; Graham, Osgood, Wells, & Stockwell, 2006; Leonard & Quigley, 1999; Murphy, Winters, O'Farrell, Fals-Stewart, & Murphy, 2005; Neal & Fromme, 2007a; Wells, Mihic, Tremblay, Graham, & Demers, 2008). For example, an examination of Canadian university students' three most recent drinking events revealed a positive association between the number of drinks consumed and aggression (Wells et al., 2008). Similarly, a large-scale, 30-day daily monitoring study of first-year U.S. college students found that aggression was more likely to occur as students' daily estimated blood alcohol concentrations (eBACs) increased (Neal & Fromme, 2007a).

Both studies failed to find support for a sex difference in alcohol-related aggression among college students. In the study of Canadian university students, women were more likely than men to report aggression, but there were no sex differences in the association between number of drinks consumed and aggression (Wells et al., 2008). As the authors noted, however, women will, on average, reach higher levels of intoxication with the same number of drinks relative to men, which could mask any difference in the magnitude of the relation between intoxication and aggression. In the 30-day daily monitoring study, women again reported more aggression than did men, but sex did not significantly interact with daily eBAC to predict aggression (Neal & Fromme, 2007a). There was, however, a non-significant trend such that alcohol intoxication was more strongly associated with men's aggressive behavior relative to that of women. Thus, additional event-level examination is needed to further understand the potential moderating role of sex.

To our knowledge, only one event-level study has investigated the role of subjective intoxication in aggression. In a 4-year extension of the same large, 30-day event-level study of U.S. college students described above, Quinn and Fromme (2011a) found that participants who reported greater typical subjective intoxication relative to their peers were more likely to aggress. Further, on days on which participants reached higher eBACs, increased daily subjective intoxication was also associated with aggression. That investigation included both drinking and non-drinking occasions, however, which may have confounded subjective intoxication with drinking versus not drinking, suggesting that further event-level research is needed to determine whether subjective intoxication contributes to alcohol-related aggression.

The goal of the present investigation was to examine whether alcohol-aggression findings from laboratory research could be replicated using data from a large, event-level study of college student drinking. Data from this study have been used in several previous event-level investigations of aggression (Neal & Fromme, 2007a; Quinn & Fromme, 2011a), yet several important questions remain. First, we sought to replicate previous findings of an association between alcohol intoxication and aggression using the full four-year sample of event-level observations, rather than just the first-year observations, which were available at the time of Neal and Fromme's (2007a) study. Second, we examined whether sex would moderate this association. Because previous research has found important sex differences in alcohol consumption and personality factors, we additionally tested whether the moderation effect would be explained by differences in typical drinking or trait-level sensation seeking. Third, we sought to determine whether subjective intoxication on drinking days was associated with aggression above and beyond objective intoxication and family history of alcohol problems, which has been linked with subjective intoxication in previous research.

Method

Participant Recruitment and Initial Survey

The present study used event-level data from a sample (N = 1,775) drawn from a longitudinal study of college student alcohol use and other behavioral risks. Several prior articles have described participant recruitment and other procedures for the larger longitudinal study (Corbin, Vaughan, & Fromme, 2008; Fromme, Corbin & Kruse, 2008; Hatzenbuehler, Corbin, & Fromme, 2008). First-time students in the incoming class of 2004 at a large, southwestern university who were aged 17 – 19 years (N = 6,391, 94% of the incoming class) were invited to participate in the longitudinal study. Of the students who met the initial inclusion criteria, 4,832 expressed interest in participating and met the final inclusion criterion of being unmarried, 3,046 of whom were randomized to the longitudinal assessment condition from which these data were drawn. In the summer prior to fall 2004 college matriculation, 74% (n = 2,245) of the students randomized to this condition completed an initial online survey, which assessed behavior for the final three months of high school. One participant was subsequently excluded when we determined that he had not met inclusion criteria, yielding a sample of 2,244.

For the purposes of the present study, we drew measures of *sensation seeking* and *family history of alcohol problems* from the initial survey. We used an 11-item scale from the Zuckerman-Kuhlman Personality Questionnaire to measure sensation seeking (Zuckerman, Kuhlman, Joireman, Teta, & Kraft, 1993). Participants responded to items such as *I'll try anything once* using dichotomous true/false response options. In the current sample, the sensation seeking scale demonstrated adequate internal consistency, $\alpha = .73$. We used the Family History Tree questionnaire to assess family history of alcohol problems (Mann, Sobell, Sobell, & Pavan, 1985). This questionnaire asks participants to assign siblings, parents, and grandparents labels of *never drank*, *social drinker*, *possible problem drinker*, *definite problem drinker*, or *don't know/don't remember*. We categorized participants with at least one definite problem-drinking relative as *family history positive* and all other participants as *family history negative*. See Table 1 for summary statistics for the included sample.

Daily Self-Monitoring Procedures

As has been described in several previous articles (Neal & Fromme, 2007a, 2007b; Quinn & Fromme, 2011a, 2012), participating students were invited to complete up to 30 consecutive days of online self-monitoring in each of the four years of college. Starting in August of the first year, sets of 40–43 students who participated in the initial survey were randomized each

week to begin their monitoring periods. To ensure adequate sample coverage during the initial weeks of the fall semester, the first randomized set included 200 students. In the three subsequent college years, participants were invited to provide daily self-monitoring during the same 30-day calendar periods, with the exception that no participants were invited during the summer of the 4th year. Each day, participants could log onto the self-monitoring website (maintained by DatStat, Seattle, WA), to provide responses regarding the previous day and night. The website presented participants with a calendar of their 30-day monitoring period, and although daily responding was encouraged, participants were permitted to provide responses for the previous seven days in order to maximize compliance and minimize retrospection. Participants were compensated $1 per day of monitoring, with a $5 bonus for completing all 30 days within a year.

Each daily survey assessed time-varying demographic variables (e.g., weight). For days or nights on which participants consumed alcohol, they were also asked to report the number of standard drinks consumed (i.e., 12 oz of beer, 5 oz of wine, or 1.5 oz of liquor in a shot or mixed drink) and the duration of the heaviest drinking episode. Using self-reported weight, sex, number of drinks consumed, and drinking duration, we calculated eBAC for each monitoring observation with the formula provided by Matthews and Miller (1979). When objective BAC measures are not available, Leeman and colleagues (2010) have recommended using eBACs, which have demonstrated strong associations with breath alcohol concentrations, particularly at levels of intoxication below .08 g% (Hustad & Carey, 2005). As a measure of subjective intoxication (SI), participants also reported how drunk they felt during the day's heaviest drinking episode on a scale from 0 (*not at all*) to 100 (*extremely*). A version of this SI item demonstrated reliability and convergent validity with another index of the subjective sedative-like effects of alcohol in the laboratory (Quinn & Fromme, 2011a). Finally, participants reported whether they *acted aggressively (e.g., became angry or engaged in verbal/physical fights)*. If participants reported engaging in aggression and consuming alcohol on the same monitoring day, they were asked to report whether the aggression occurred *when* [they] *had not been drinking*, *when* [they] *had been drinking*, or both.

Of the 2,244 participants in the longitudinal study, 2,015 provided 155,219 daily self-monitoring observations across the 4 years. After excluding 2 participants and 948 observations for missingness on aggression or eBAC, sensation seeking and family history were available from the initial survey data for 95% of the self-monitoring participants (n = 1,911). We took several steps, consistent with previous studies using this sample, to maximize the reliability and validity of the self-monitoring data. First, we included data only from participants' yearly monitoring periods in which they provided at least 14 days of monitoring in order to reduce bias due to overexclusion or inclusion of noncompliant participants. Second, we excluded 229 observations on which eBACs were greater than or equal to .40 g% (.16% of otherwise included observations), resulting in a final sample of 1,775 participants with 140,618 total observations. The included sample was 63% female (54% White, 19% Asian/Asian-American, 14% Hispanic/Latino, 4% African-American, and 9% multiethnic, other ethnicities, or no reported ethnicity).

Analytic Approach

Each participant provided multiple daily self-monitoring reports. Given this lack of independence of observations within participants, we tested event-level associations between alcohol intoxication and aggression using two-level (observations within participants) Generalized Estimating Equations in Stata version 11.0 (GEE; Hardin & Hilbe, 2003). We expected *a priori* that an autoregressive correlation structure would be appropriate given the sampling method (i.e., consecutive daily reports within each year).[1]

Because aggression was a dichotomous variable, we specified the binomial reference distribution and logit link, and we reported results using Stata's robust standard error option.

Our primary research questions concerned the event-level associations between increasing alcohol intoxication (objective and subjective) and aggression. We therefore created daily eBAC and SI variables by centering each variable at the person mean (e.g., daily eBAC = eBAC − person-mean eBAC). Person-mean centering permitted an assessment of the purely within-person association between changes in intoxication and changes in the likelihood of engaging in aggression independent of any between-persons relations (Enders & Tofighi, 2007; Raudenbush & Bryk, 2002). For example, if individuals who are more aggressive relative to their peers also drink more heavily, then any daily covariation between drinking and aggression may be confounded. Person-mean centering daily eBAC, however, reduces this possibility by removing between-persons variation in eBAC. We additionally included average (i.e., person-mean) eBAC and SI variables in all models to test for between-persons associations.

Of the 140,618 included daily observations, participants reported aggression on 2,127 days (1.51%). Of the 608 days on which aggression occurred *and* eBACs were non-zero, participants reported that 132 of the aggression events occurred when they had not been drinking. Because the event-level analyses were intended to determine whether within-person increases in alcohol intoxication *predicted* aggression, we recoded daily eBAC and SI values for these instances (i.e., when aggression preceded drinking on the same day) to 0 prior to centering. In creating the average eBAC and SI variables, however, we retained all eBAC and SI values, regardless of daily temporal ordering with aggression.

We included a number of within- and between-persons covariates in our GEE analyses. Dummy-coded day-of-week indicators (with Sunday as the reference day) were included to control for weekly variation in aggression. We also included two variables representing monitoring year (range: 1 – 4) and within-year monitoring day (range: 1 – 30). Both variables were person-mean centered and were included to control for changes in aggression across years and monitoring periods, respectively. Family history and sensation seeking were included as between-persons covariates. We centered between-persons variables (family history, sensation seeking, and average eBAC and SI) at the grand mean (e.g., average eBAC = person-mean eBAC − person-mean eBAC averaged across all individuals). Sex, however, was coded such that 0 = *female* and 1 = *male* to aid interpretation of model parameters. In order to further aid interpretation, we multiplied all eBAC values by 100 and divided all SI values by 10 prior to analyses. Odds ratios therefore reflected changes in odds of aggression associated with a .01 g% increase in eBAC or a 10-point increase in SI.

Finally, for analyses that included SI as a predictor of aggression, we limited our models to drinking occasions only (defined as monitoring reports in which eBACs exceeded zero). We also excluded any observations on which aggression preceded (but did not follow) drinking during the same day. Because at least two observations per person are required for the autoregressive correlation structure, these models additionally excluded 114 participants who provided only 1 drinking-day observation. The final sample for these models comprised 19,490 drinking days among 1,347 non-abstaining participants (64% female). We used the same centering procedures as were applied to the full sample, although person and grand means were computed across the included drinking days only.

[1]We also repeated our final models using an exchangeable correlation structure. These analyses produced results comparable in both magnitude and significance to those reported here for our primary research questions (i.e., the moderation by sex of the event-level association between eBAC and aggression and the associations between SI and aggression).

Results

Aggregate Sex Differences

As shown in Table 1, female participants were modestly but significantly more likely to report aggression relative to men. Women reported consuming fewer drinks per monitoring day but showed higher eBACs, which adjusted for weight and sex. Women were also more likely to report a positive family history of alcohol problems.

Similar patterns emerged in the drinking-days subsample, in which women reported consuming fewer drinks per drinking day but reaching significantly higher eBACs. On average, women exceeded the NIAAA definition of binge drinking (.08 g%; NIAAA, 2004) on drinking days, whereas men approached but did not reach that criterion. Despite reaching higher eBACs, however, women reported lower levels of average SI on drinking days relative to men. Table 2 displays between-persons correlations among study variables for the full and drinking-days-only samples.

Event-Level Association between Alcohol Intoxication and Aggression

Replicating previous research using both laboratory-based and event-level methods, the GEE models produced evidence of an event-level association between alcohol intoxication and aggression. A .01 increase in daily eBAC was associated with a 6% increase in the odds of aggression. See Table 3, Model 1. Beyond this association, aggression was more likely on Fridays and Saturdays, and participants were less likely to report aggression in later monitoring days (within years) and in the later college years. In addition, we also found several between-persons associations: Female participants and heavier drinkers (i.e., those higher in average eBAC) were more likely to report aggression, whereas neither sensation seeking nor family history were associated with aggression.

Moreover, consistent with findings from laboratory studies, the event-level association between daily eBAC and aggression was significantly stronger among men relative to women. See Table 3, Model 2. The event-level eBAC-aggression association was also significantly stronger among those higher in sensation seeking, but it did not differ as a function of average eBAC, and the eBAC-sex interaction remained significant controlling for interactions with sensation seeking and average eBAC. To ensure that the inclusion of non-significant predictors did not bias the associations of interest, we estimated a final model in which we trimmed the non-significant family history main-effect and daily × average eBAC interaction terms. As shown in Table 3, Model 3, results were consistent in the trimmed model. As displayed in Figure 1, increasing daily eBAC was associated with an increased probability of aggression among participants of both sexes, but the association was significantly stronger among men relative to women. A .01 g% increase in eBAC was associated with an 8% increase in the odds of aggression for men but a 5% increase in the odds of aggression for women.

Because these analyses included four years of self-monitoring, it is possible that year-to-year changes in drinking and aggression may have confounded the event-level associations. For example, if a given participant drank more and aggressed more during their second monitoring year relative to the other monitoring years because of external factors (e.g., affiliation with a more deviant peer group), this year-based deviation from average for both behaviors might produce a spurious event-level association. We therefore repeated our final model (Model 3) centering daily eBAC at the person-year-mean but retaining all other modeling specifications. This model tested whether within-year, within-person increases in eBAC were associated with increases in the likelihood of aggression. We again found the event-level association between eBAC and aggression was significantly stronger among men ($b = 0.04$, $OR = 1.04$, $p < .001$) and those higher in sensation seeking ($b = 0.004$, $OR =$

1.004, $p = .047$). Thus, we found no evidence that year-to-year changes in study variables produced false-positive event-level associations.

Event-Level Association between Subjective Alcohol Intoxication and Aggression

Our next research question concerned the contribution of SI to the alcohol-aggression relation. We began by adding daily and average SI to the full model described above in the subset of monitoring days in which participants reported a positive eBAC (19,490 observations among 1,347 participants). As shown in Table 4, Model 4, we found evidence of event-level *and* global associations between SI and aggression. Participants were more likely to engage in aggression during drinking episodes in which they reported greater SI. Specifically, controlling for daily eBAC, a 10-point increase in daily SI was associated with a 15% increase in the odds of aggression at the event level. Further, participants who, on average, tended to report greater SI were also more likely to report aggression. A 10-point increase in average SI was associated with a 25% increase in the odds of aggression controlling for average eBAC.

Beyond the SI associations, the results of the initial drinking-days-only model were largely consistent with those of the models including drinking and non-drinking days (i.e., Models 1–3). Participants reported more drinking-day aggression on Saturdays and less drinking-day aggression during later monitoring days and monitoring years. Several between-persons associations were also consistent, with women and heavier drinkers reporting more drinking-day aggression. Most important, the event-level association between daily eBAC and drinking-day aggression was again stronger among men relative to women. In contrast to the results including drinking and non-drinking days, however, the event-level eBAC-aggression association did not differ as a function of sensation seeking, although it was significantly stronger among lighter drinkers.

Given the significant event-level and global associations between SI and aggression, we explored whether these relations differed across eBAC and sex by running separate models in which we added each interaction term to Model 4. We first tested whether the event-level association between SI and aggression was stronger at higher eBACs. The interaction between daily SI and daily eBAC did not reach significance, however, and was opposite to the expected direction, $b = -0.004$, $OR = 0.996$, $p = .055$. Similarly, the association between average SI and aggression did not differ as a function of daily eBAC, $b = 0.01$, $OR = 1.01$, $p = .21$. Because sex moderated the daily eBAC-aggression association, we also examined whether the SI associations differed across sexes. Neither the daily ($b = 0.04$, $OR = 1.04$, $p = .49$) nor average ($b = 0.14$, $OR = 1.15$, $p = .12$) SI associations, however, was significantly moderated by sex. Parameter estimates from the final trimmed model without the non-significant main effects and moderators, which were comparable to those from the full model, are shown in Table 4, Model 5.

Finally, we repeated the trimmed model centering daily eBAC and SI at person-year-means rather than the overall person-means to ensure that the subjective intoxication associations were not biased by year-to-year variation in the person-centered models. In this model, participants were again at greater risk of aggression during drinking events in which they reported greater daily SI ($b = 0.14$, $OR = 1.15$, $p < .001$) controlling for daily eBAC. Further, controlling for average eBAC, participants who tended to report greater SI on average also reported more aggression, $b = 0.22$, $OR = 1.25$, $p < .001$. In addition, the association between daily eBAC and aggression was again significantly stronger among men ($b = 0.05$, $OR = 1.05$, $p < .001$) and among those lower in average eBAC, $b = -0.005$, $OR = 0.995$, $p = .004$. In sum, the results of the final model were again consistent when using person-year-mean centering.

Discussion

Experimental research has consistently found that alcohol can increase aggression in the laboratory (Giancola et al., 2010). Laboratory-based paradigms such as those often used in aggression research have a number of methodological advantages. They can include a high degree of experimental control, and randomization to conditions (e.g., alcohol vs. placebo) permits causal inferences about the ways in which alcohol intoxication can affect aggressive responding. Nevertheless, these approaches have limitations as well. Most notably, experimental and ethical restrictions necessitate the assessment of aggression using analogue tasks rather than actual behavior, and they constrain levels of alcohol consumption and intoxication. As a consequence, conclusions from these studies are limited in the face of inconsistent findings or concerns regarding task validity.

In the current study, we used a different methodology—an event-level study in the natural environment—to attempt to resolve two research questions regarding the link between alcohol and aggression. First, although laboratory research has consistently found that alcohol intoxication increases aggressive responding in men, it has tended to find a much weaker effect in women. This pattern has led some to conclude that alcohol's impact on aggression is less strong among women (e.g., Giancola et al., 2009). Others, however, have raised questions about the validity of the tasks used to assess aggression (Tedeschi & Quigley, 1996).

The results of the current study generally converged with those from laboratory research. Consistent with experimental studies and prior event-level studies, we found a significant event-level association between drinking and aggression (e.g., Neal & Fromme, 2007a; Wells et al., 2008). More important, this association was significantly stronger among men relative to women. It is important to note that this finding differs from the non-significant sex-moderation effect found by Neal and Fromme (2007a) in a subset of the dataset used here. Given that the effect sizes were very similar across both studies (see Table 4 of Neal & Fromme, 2007a), it is likely that the significant moderation effect found here was due to our larger sample of observations. In sum, in a very large sample of drinking observations among college students and using eBACs to decrease sex bias in the measurement of alcohol consumption (cf. Wells et al., 2008), the current findings support a sex difference in the association between alcohol intoxication and aggression. Extrapolating from our results, an increase of .08 g% in eBAC (i.e., the NIAAA definition of binge drinking) would be associated with a 44% increase in the odds of aggression for women but a 90% increase for men.

Converging findings across methodologies provide compelling evidence that alcohol may impact aggression differently in men and women and that the results of laboratory studies may not be fully explained by methodological artifacts. Although beyond the scope of this study, there are several possible explanations for these differences, each of which can be tested in future research. We found that the event-level association between eBAC and aggression was stronger among those higher in sensation seeking but that this difference did not fully explain the moderation of the association by sex. Nevertheless, other trait-level differences between men and women that were not assessed in this study may explain the stronger impact of alcohol among men (e.g., irritability, anger, or aggressivity; Giancola, 2002a, 2002b, 2002c). Further, social learning perspectives suggest that men may be more aggressive because of traditional gender-role socialization (Eagly & Wood, 1991), and Cloninger and colleagues (1975, 1978) posit that women have a higher threshold for aggression than do men.

The current finding that women reported more aggression overall than did men may, however, argue against these potential explanations. It may rather be that alcohol plays less of a role in aggression for women than men, which is consistent with recent survey research on men's and women's intimate partner violence (Testa et al., 2012). This difference may be explained by contextual differences associated with alcohol use that encourage male aggression over female aggression. As predicted by Alcohol Myopia Theory (Giancola et al., 2010; Steele & Josephs, 1990), cues that impel men's aggression may be more prominent in social drinking environments than are cues for women's aggression. Understanding event-specific contextual factors, including the severity and function of the aggressive behavior, as well as information about the target of the aggression (e.g., alcohol consumption, relationship to the aggressor) will be important to fully describing this sex difference.

The other research question addressed here concerned the role of SI in alcohol-related aggression. We found evidence that SI was associated with aggression in two ways. First, participants were more likely to report aggression on drinking occasions in which they reported greater SI. Controlling for daily eBAC, a 10-point increase in daily SI was associated with a 15% increase in the odds of aggression. Second, students who experienced greater SI on average were more likely to engage in aggression on drinking days. Controlling for typical drinking, a 10-point increase in average SI was associated with a 25% increase in the odds of aggression. Neither the daily nor average SI associations were significantly moderated by daily eBAC or sex, suggesting that greater subjective levels of intoxication were associated with acting more aggressively regardless of sex or how many drinks students consumed.

The current study differed in several ways from a prior event-level study of SI and aggression using these data (Quinn & Fromme, 2011a). The present models included drinking days only, which eliminated the possibility of bias due to the lack of meaningful SI variability in the absence of alcohol consumption. Additionally, we report results here using robust standard errors, grand-mean centering for person-level variables, and person-mean centering of eBAC and SI, although we also describe comparable results using person-year-mean centering. Despite these differences, the SI results were generally consistent across studies, with the notable exception that the previous study found a stronger event-level association between SI and aggression at higher eBACs (when including non-drinking days), whereas, in this study, the daily eBAC x daily SI interaction was only marginally significant and was in the opposite direction. Nevertheless, the significant overall main effect of daily SI found here may be consistent, in interpretation at least, with the previous finding, given that this study only included days with eBACs greater than zero.

If the current SI results can be replicated in other samples, it is likely that differing mechanisms account for the daily and average SI associations with aggression. Evidence that at least some subjective responses to the effects of alcohol can vary across social settings (Ray, Miranda et al., 2010), taken with the role of contextual cues in alcohol-related aggression (Giancola et al., 2010), suggests that drinking context may drive the event-level association between SI and aggression. Determining whether SI plays a causal role in this pathway will require future research using experimental methods or ecological momentary assessment. In contrast, individual differences in average SI may reflect alcohol expectancies, personality factors, or individual variability in responses to alcohol's physiological, hedonic, or cognitive effects. Although our results argue against confounding by typical alcohol consumption, family history, or sensation seeking, the relatively sparse research literature on SI and aggression suggests that future research is needed to examine these other possibilities.

Like all research methodologies, the approach used here has important limitations. Beyond its reliance on self-report and lack of placebo control, this study assessed day-to-day covariation between intoxication and aggression rather than exact temporal linkages. It is therefore important to note that the event-level associations may have resulted from post-hoc attributions by participants. Having engaged in aggression may have led participants to believe—and therefore report—that their levels of objective or subjective intoxication were higher. Moreover, lacking randomization and experimental control, our results do not permit causal inferences. The within-person association between alcohol intoxication and aggression was stronger among men than among women, for example, but we cannot infer that alcohol intoxication caused increases in aggression in either sex in this study.

In addition, several limitations in measurement are notable. First, although it may be preferable to assess alcohol consumption using eBACs rather than counts of drinks consumed, eBACs are imperfect measures of blood alcohol concentrations (e.g., Grant, LaBrie, Hummer, & Lac, 2012). eBACs rely on self-reported consumption and weight, and they may be influenced by any bias in reporting. Second, our SI measure was a global assessment of perceived intoxication rather than a specific assessment of the subjective stimulant-like or sedative-like effects of alcohol. Replication using comprehensive, more thoroughly validated subjective measures is needed. Third, without structured clinical interviews and reports from family members, our measure of family history of alcohol problems may have limited our ability to detect associations between family history and aggression. Finally, the measure of aggression used here included verbal and physical aggression, in addition to anger, and the target of the aggression was not known. This breadth of aggressive outcomes increased the base endorsement rate for this relatively rare behavior, but it did so at the expense of specificity. Moreover, experiencing anger does not necessarily lead to the behavioral expression of aggression, although it has been shown to increase aggression in laboratory studies (Eckhart, 2007).

Despite these limitations, the strengths of our event-level approach complement the advantages of laboratory paradigms. In particular, event-level studies such as this investigation can include large samples and provide greater ecological validity with respect to alcohol consumption and aggressive behavior. As this study demonstrates, replication of findings across methodologies can help reduce concerns about the particular limitations of a single approach and thereby increase confidence in inferences from those findings.

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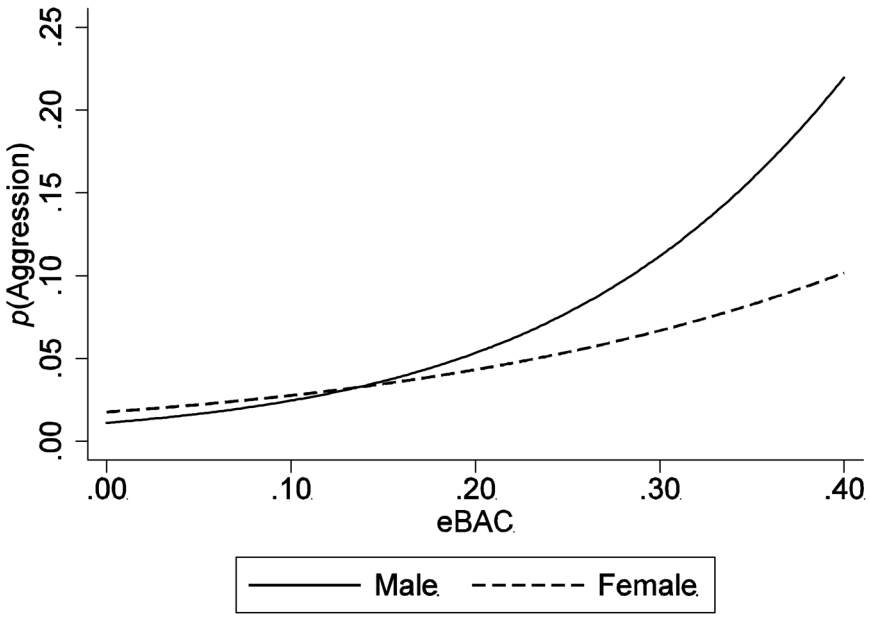

Figure 1.
Predicted probability of aggression as a function of daily estimated blood alcohol concentration (eBAC) among male and female participants from Model 3. For illustrative purposes, estimates are shown for probabilities of aggression on Saturdays (i.e., the day on which aggression was most common) at the average of person-mean eBAC (i.e., to display aggression estimates for specific eBAC values rather than for deviations from person-mean levels).

Table 1

Aggregate Summary Statistics

Variable	Observed Range	Female (n = 1,111)		Male (n = 664)		Effect Size[b]
		M	*SD*	*M*	*SD*	
Included monitoring days	7 – 120[a]	**80.65**	**32.40**	**76.83**	**33.61**	**.12**
Drinks per day	0 – 8.95	*0.56*	*0.75*	*0.80*	*1.20*	*−.24*
eBAC per day (g%)	0 – 0.16	**0.014**	**0.019**	**0.012**	**0.019**	**.10**
Sensation seeking	0 – 11	*5.24*	*2.72*	*5.91*	*2.56*	*−.26*
Family history positive [95% C.I.]	--	**24% [22%, 27%]**		**20% [17%, 23%]**		**.10**
Aggression [95% C.I.]	--	**38% [35%, 41%]**		**32% [29%, 36%]**		**.12**
Drinking Days Subsample (n = 1,347; 64% female)						
Included drinking days	2 – 86	14.37	12.38	14.65	13.10	−.02
Drinks per drinking day	1 – 14.5	*3.42*	*1.56*	*4.77*	*2.61*	*−.63*
eBAC per drinking day (g%)	0.004 – 0.29	**0.086**	**0.044**	**0.073**	**0.044**	**.28**
SI per drinking day	0 – 90	*24.39*	*17.39*	*26.52*	*19.63*	*−.11*

Note. Bolded values were significantly greater among women; italicized values were significantly greater among men, ps < .05. Aggression variable scored dichotomously (0 = *did not engage in aggression*, 1 = *engaged in aggression at least once*).

eBAC = estimated blood alcohol concentration. SI = subjective intoxication.

[a]Participants were excluded if they did not provide 14 or more days of self-monitoring in at least 1 30-day monitoring period. For one participant who provided 26 days of monitoring during one year, however, 19 of the 26 observations were excluded because of missingness on study variables, resulting in only 7 included monitoring days.

[b]Effect sizes are Cohen's *d* for means and *h* for proportions. Positive effect sizes indicate greater scores for women relative to men.

Table 2

Between-Persons Correlations among Study Variables

Variable	1	2	3	4	5	6
1. Male sex	--					
2. Family history positive	−.05*	--				
3. Sensation seeking	.12*	.05*	--			
4. eBAC per day	−.05*	.09*	.16*	--		
5. Aggression	−.06*	.06*	.06*	.20*	--	
Drinking Days Subsample						
6. eBAC per drinking day[a]	−.13*	.05	.12*	.68*	.17*	--
7. SI per drinking day[a]	.06*	.11*	.10*	.43*	.18*	.58*

Note. Aggression variable scored dichotomously (0 = *did not engage in aggression*, 1 = *engaged in aggression at least once*).

eBAC = estimated blood alcohol concentration. SI = subjective intoxication.

[a]Correlations are for drinking days subsample (n = 1,347 non-abstainers).

*$p < .05$.

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Table 3

Generalized Estimating Equation Models Predicting Aggression

Variable	Model 1			Model 2			Model 3		
	b	***OR***	**95% C.I. *OR***	***b***	***OR***	**95% C.I. *OR***	***b***	***OR***	**95% C.I. *OR***
Intercept	−4.26*	--	--	−4.24*	--	--	−4.23*	--	--
Between-persons									
Male sex	−0.33*	0.72	0.53, 0.98	−0.41*	0.66	0.47, 0.93	−0.43*	0.65	0.46, 0.92
Family history positive	0.22	1.25	0.96, 1.62	0.21	1.24	0.95, 1.60			
Sensation seeking	−0.01	0.99	0.94, 1.04	−0.02	0.98	0.93, 1.03	−0.02	0.98	0.94, 1.04
Average eBAC	0.09*	1.10	1.04, 1.15	0.09*	1.10	1.04, 1.16	0.09*	1.10	1.05, 1.15
Within-person									
Monday	−0.10	0.91	0.77, 1.07	−0.10	0.91	0.77, 1.07	−0.10	0.91	0.77, 1.07
Tuesday	−0.10	0.90	0.77, 1.06	−0.10	0.91	0.77, 1.06	−0.10	0.90	0.77, 1.06
Wednesday	−0.15	0.86	0.72, 1.03	−0.15	0.86	0.72, 1.04	−0.15	0.86	0.72, 1.03
Thursday	0.05	1.05	0.90, 1.23	0.05	1.06	0.90, 1.24	0.05	1.05	0.90, 1.23
Friday	0.16*	1.18	1.02, 1.37	0.16*	1.18	1.01, 1.37	0.17*	1.18	1.02, 1.37
Saturday	0.27*	1.31	1.14, 1.52	0.28*	1.32	1.14, 1.52	0.28*	1.32	1.15, 1.53
Monitoring day	−0.03*	0.97	0.96, 0.97	−0.03*	0.97	0.96, 0.97	−0.03*	0.97	0.96, 0.97
Monitoring year	−0.30*	0.74	0.69, 0.79	−0.30*	0.74	0.69, 0.79	−0.30*	0.74	0.69, 0.79
Daily eBAC	0.06*	1.06	1.05, 1.07	0.05*	1.05	1.04, 1.06	0.05*	1.05	1.04, 1.06
Moderators of the daily eBAC-aggression association									
Male sex				0.03*	1.03	1.01, 1.06	0.03*	1.04	1.02, 1.06
Average eBAC				0.00	1.00	1.00, 1.00			
Sensation seeking				0.004*	1.004	1.0003, 1.01	0.003*	1.004	1.0002, 1.01
χ^2 (*df*)	459.26* (13)			475.75* (16)			458.62* (14)		

Note. Model 3 is the final, trimmed model.

OR = Odds ratio. eBAC = Estimated blood alcohol concentration.

* $p < .05$.

Table 4

Generalized Estimating Equation Models Predicting Aggression on Drinking Days

Variable	Model 4			Model 5		
	b	***OR***	**95% C.I. *OR***	***b***	***OR***	**95% C.I. *OR***
Intercept	−4.74*	--	--	−4.74*	--	--
Between-persons						
Male sex	−0.46*	0.63	0.44, 0.90	−0.46*	0.63	0.44, 0.90
Family history positive	0.02	1.02	0.75, 1.39			
Sensation seeking	0.06	1.06	1.00, 1.13	0.07*	1.07	1.01, 1.13
Average eBAC	0.11*	1.11	1.06, 1.17	0.11*	1.11	1.06, 1.17
Average SI	0.22*	1.25	1.13, 1.39	0.22*	1.25	1.13, 1.38
Within-person						
Monday	0.52	1.68	0.91, 3.08	0.52	1.68	0.92, 3.09
Tuesday	0.39	1.48	0.83, 2.61	0.39	1.48	0.83, 2.62
Wednesday	−0.23	0.80	0.40, 1.59	−0.22	0.80	0.40, 1.59
Thursday	0.14	1.15	0.68, 1.94	0.15	1.16	0.68, 1.95
Friday	0.46	1.58	0.98, 2.56	0.46	1.59	0.98, 2.57
Saturday	0.69*	1.99	1.23, 3.25	0.69*	2.00	1.23, 3.26
Monitoring day	−0.01*	0.99	0.98, 0.9995	−0.01*	0.99	0.98, 0.9995
Monitoring year	−0.16*	0.86	0.76, 0.96	−0.16*	0.85	0.76, 0.95
Daily eBAC	0.05*	1.05	1.02, 1.07	0.05*	1.05	1.02. 1.07
Daily SI	0.14*	1.15	1.10, 1.21	0.14*	1.15	1.10, 1.21
Moderators of the daily eBAC-aggression association						
Male sex	0.04*	1.05	1.02, 1.07	0.05*	1.05	1.02, 1.07
Average eBAC	−0.004*	0.996	0.99, 0.999	−0.004*	0.997	0.99, 0.999
Sensation seeking	0.00	1.00	1.00, 1.01			
χ^2 (*df*)	510.15* (18)			478.07* (16)		

Note. Models estimated in drinking days subsample. Model 5 is the final, trimmed model.

OR = Odds ratio. eBAC = Estimated blood alcohol concentration. SI = Subjective intoxication.

* $p < .05$.