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Coping Motives and Negative Affect: An Ecological Study of the Antecedents of Alcohol Craving and Alcohol Use

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Abstract

Objective: Negative affect is presumed to be an important trigger for drinking, particularly among coping-motivated drinkers. However, diary studies attempting to predict alcohol use from interactions between state negative affect and coping motives have proved inconsistent. Craving or momentary desire for alcohol may be a more proximal and robust consequence of negative affect in coping-motivated drinkers.

Method: Data were drawn from an ecological momentary assessment investigation. Frequent drinkers (N = 403) carried electronic diaries for 21 consecutive days, recording their drinking behavior, and rating cravings for alcohol and negative affect.

Results: Outside of active drinking episodes, within-person elevations of momentary negative affect were associated with increased craving intensity, and this effect was more prominent among drinkers with higher dispositional coping motives. There was no significant interaction between coping motives and momentary negative affect in predicting the occurrence and amount of same day alcohol use. Significant conditional indirect effects indicated that negative affect promoted drinking through increases in craving. These indirect effects were stronger among drinkers reporting higher coping motives.

Conclusions: Coping motives and within-person fluctuations in negative affect interactively predict alcohol craving. Negative affect promotes drinking indirectly via increased craving, particularly among coping-motivated drinkers. Alcohol craving may be a proximal and sensitive response channel for investigating interactions between affective distress and coping motives.

Keywords

Negative Affect; Coping Motives; Alcohol Craving; Self-Medication; Ecological Momentary Assessment

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Motivational models of alcohol use posit that one decides to drink based on beliefs regarding how alcohol will affect one's behavior, mood, and social standing (Cooper, 1994; Cox & Klinger, 1988; 1990). These models suggest that historical and current factors (e.g., alcohol-related social learning and situational context) lead to the acquisition of personally relevant alcohol outcome expectations, which will encourage either approach toward or avoidance of alcohol use (Cooper 1994; Kuntsche et al., 2005; Corbin et al., 2020).

Drinking to cope, which represents an internal, avoidance-oriented motive, is characterized by the desire to counteract negative affect through alcohol use. Researchers have been keenly interested in developing a better understanding of coping motives because they predict heavy alcohol use and are associated with alcohol-related problems even when controlling for other motives and elevated levels of use (Beseler, et al., 2008; Carpenter & Hasin, 1998; 1999; Cook, et al., 2019; Cooper, et al., 1995; Martens et al., 2008; McNally, et al., 2003; Merrill & Read, 2010; Merrill, et al., 2014; Simons, et al., 2000; Stevenson et al., 2019; Waddell et al., 2020). Accordingly, there has been great interest in modeling the theoretically appealing interplay between global coping motives, daily negative affect, and daily drinking using ecologically-valid, experience sampling methods. The motivational models of Cooper (1994) and Cox and Klinger (1988) imply that drinkers' experience of negative mood states will be associated with near-term alcohol use, and that this association will be moderated by coping motives. Specifically, an individual who holds stronger coping motives is expected to be especially likely to drink on a day when he or she experiences higher levels of negative emotion. However, several studies testing this fundamental hypothesis have found discrepant results – some find an interaction in the hypothesized direction (Mohr et al., 2005; Todd et al., 2005; Armeli et al., 2010) and one study found an interaction in the opposite direction (Hussong, et al., 2005). In addition, other findings indicate no interaction (Armeli et al., 2010; Carney, et al., 2000; Todd, et al., 2003) or provide evidence for a stronger association between negative affect and drinking among those holding lower coping motives (Todd et al., 2003; Grant et al., 2009)

In response to these equivocal findings, researchers have explored the possibility that one's negative affect may not be an immediate antecedent of daily drinking, but rather that elevated levels of negative affect at the beginning of the week may predict earlier weekly drinking initiation (Armeli, et al., 2008; Hussong, 2007; Littlefield, et al., 2012; O'Hara, et al., 2014). Using a survival analysis framework, Hussong (2007) found that coping motives predicted faster progression to drinking after elevated sadness, although this was qualified by the presence of alcohol problems in men. Using a similar approach, Armeli et al. (2008) found that drinkers holding stronger coping motives drank sooner in weeks characterized by elevated levels of anxiety. However, other investigations have yielded null effects (Littlefield et al., 2012) or findings in the opposite direction to those suggested by motivational models (O'Hara et al., 2014). Thus, using time-to-drink models have not resolved the empirical inconsistency. Investigators have also tried using different measures of drinking behavior (e.g., amount of drinking, drinking day, or time to drink) to clarify discrepant findings, but the relationship is still unclear (e.g., Littlefield et al., 2012, O'Hara et al., 2014).

The premise behind the current study is that the occurrence of drinking behavior per se is complexly determined and subject to numerous, powerful internal and external influences

(e.g., habit, limit-setting, social norms, alcohol availability). This may make drinking a potentially insensitive (albeit theoretically relevant) outcome measure for evaluating the interplay between coping motives and negative affective states. Drinking is prohibited or socially proscribed in many situations, and this may restrict its occurrence irrespective of any contemporaneous, drinking-promoting psychological processes. Similarly, temporally adjacent situations (e.g., needing to drive, future work, or school obligations) may inhibit immediate drinking even when it is allowed in the moment. In short, there are likely many situations in which a person could be psychologically inclined to drink but does not go on to do so.

Rather than looking at drinking behavior/initiation as the target variable in coping motive research, it may be more tractable to predict the *desire* to drink (i.e., alcohol craving), which is not subject to the same constraints and potential barriers that drinking behavior is subject to. Investigating links between coping motives and craving is also theoretically appealing: coping motives reflect a dispositional propensity to be motivated or driven to drink when distressed. Acute craving for alcohol is a proximal momentary state that can represent an expression of this trait-like disposition, as both represent a motivation/desire to drink. In turn, this acute state may or may not lead to drinking as a more distal outcome. Some studies show that craving is associated with overall and subsequent drinking (De Wit, 2000; Fazzino, et al., 2013), yet other studies show that craving is not associated with drinking (De Wit, 2000; MacKillop et al., 2010; Serre, et al., 2015). Thus, negative affect and coping motives could lead one to desire alcohol, but this urge/desire may not be compelling enough to initiate drinking behavior.

The present study sought to examine how drinking motives and momentary negative affect interact to predict concurrent craving and drinking in an ecological momentary assessment study. We predicted that elevated negative affect would interact with dispositional coping motives to predict momentary craving, but that this interaction may not be evident when predicting drinking outcomes. We also tested whether there were indirect effects of negative affect on drinking that operated through increased craving and tested whether any such effects were moderated by coping motives.

Methods

Participants.

Frequent drinkers were recruited from a Midwest community via print advertisements, flyers, and mass email announcements for participation in a three-week ecological momentary assessment (EMA) study. Because the major aim of the larger study focused on alcohol and tobacco use (Piasecki et al., 2011), nearly two thirds of study participants who went into the field with a diary were current cigarette smokers ($n = 258$). Volunteers were screened for participation and had to speak English, be over 18 years of age, and report drinking alcohol at least once a week for the past month. Exclusion criteria included seeking treatment for an alcohol use disorder, trying to cut down drinking, having a history of arrests for alcohol-related offenses, or reporting use of tobacco in a non-cigarette form. A total of 403 of these participants participated in the EMA monitoring phase. Of these, 50.1% were female ($n = 202$), and 84.7% were White/Caucasian ($n = 344$). Ages ranged from 18 to 70,

with an average age of 23.3 (*SD* = 7.2). All participants provided written informed consent, and the study protocol was approved by the Institutional Review Board (IRB) at both the University of Missouri and Washington University School of Medicine.

Procedure.

After an initial phone screen, participants attended a laboratory visit during which they were administered a battery of questionnaires. Participants returned to the lab 1–2 days later for electronic diary training and began recording diary information immediately after this session for 21 consecutive days.

Electronic Diary Protocol.

Personal digital assistants (Palm m500, Palm Inc., Sunnyvale, CA) running custom diary software developed by invivodata, Inc. (Pittsburgh, PA) were used to collect ecological data. Participants were instructed to make five different types of reports. *Morning reports* (*n* = 7,424; 92% compliance) were daily reports to be completed shortly after participants woke up. Each device was programmable as an alarm clock, and thus participants could use it as a reminder to fill out the assessment when waking each day. Morning reports had to be made before 12 noon and became inaccessible after this time (i.e., participants who slept past noon were not able to make a morning report). Each participant also received up to five *random prompts* (*n* = 26,950; 77% compliance), which could be sent any time between the morning report (or noon for those who did not initiate a morning report) and reported sleep for the evening. The timing of random prompts was constrained by the requirement that no two signals would be delivered within 30 minutes of one another. When a participant used a cigarette, he or she was asked to fill out a *cigarette report* (*n* = 6,605), which included an assessment of subjective affective states. Each day was divided into four 6-hour blocks, in which only the first cigarette in each block was followed by a full assessment to reduce burden on heavy smokers. If participants logged additional cigarettes within each 6-hour period, the participant was thanked and not asked any further questions. Lastly, participants were asked to record a *drink report* (*n* = 2,108) after consuming the first drink of alcohol in a drinking episode. Subsequent *drinking follow-ups* (*n* = 8,435; 82% compliance) occurred 30 minutes after the initial drinking report, and then at hourly intervals. This sequence continued until three hours had elapsed without reported consumption or the participant reported that he/she went to bed for the night. Random prompt assessments and cigarette reports also asked whether any drinking had occurred since the last diary entry. Endorsement of drinking in these record types also triggered the drinking follow-ups. Random prompts were suspended during active drinking episodes.

Diary Measures.

Momentary Negative Affect.—Reports of mood were assessed by momentary feelings of five affective mood states (i.e., enthusiastic, excited, happy, distressed, sad) rated on a five-point scale from 1 (not at all) to 5 (extremely). Negative affect was assessed by averaging the scores of “distressed” and “sad” (α=.88), consistent with prior reports from this study (e.g., Epler, et al., 2014; Piasecki et al., 2011; Trela et al., 2018; Treloar et al.,

2015). Scores for “enthusiastic,” “excited,” and “happy” were averaged to represent positive affect in exploratory analyses.

Time and Day.—Diary record date/time stamps were used to create a time of day variable, which was dummy coded into either morning (6 am – 11 am), afternoon (12 pm – 4 pm), or night (5 pm – 6 am). A weekend variable was also created, with weekends (between Thursday at 6 pm and Sunday at 6 pm) and weekdays (between Sunday at 6 pm and Thursday at 6 pm) coded as 1 and 0, respectively. This classification was selected because young adult drinking is heightened during on these days (e.g., Del Boca, et al., 2004; Wood, et al., 2007).

Momentary Alcohol Craving.—Alcohol craving was assessed in all diary reports. Participants were asked to rate agreement with the statement “I crave a drink” on a scale of 1 (not at all) to 5 (extremely).

Daily Alcohol Consumption.—Daily drinking was calculated for each day from real-time reports. When participants logged a first drink report or endorsed recent drinking in a random prompt or cigarette report, they were not explicitly asked to report the number of drinks. These initial drink logs were counted as one drink. In subsequent drinking follow-ups, participants were asked to report the number of drinks consumed since the last report using a checklist with options 0, 1, 2, 3, 4, 5, and “6 or more” (scored as 6 in the current analyses). The number of drinks was summed across the initial drink report and completed follow-ups logged on each person-day to determine the total number of drinks consumed. Days without drinking reports were assigned a score of zero drinks on the count variable.

Baseline Measures.

Drinking Motives.—The Drinking Motives Questionnaire-Revised (DMQ-R; Cooper, 1994) was used to assess drinking motives. Participants reported how often they drink for particular reasons on a 5-point scale ranging from 1 (almost never/never) to 5 (almost always/always). Motives are divided into social (α = .86, e.g., “Because it makes social gatherings more fun”), conformity (α = .83, e.g., “Because your friends pressure you to drink”), enhancement (α = .83, e.g., “Because it gives you a pleasant feeling”), and coping (α = .78, e.g., “Because it helps you when feel depressed or nervous”) scales.

Smoking Frequency.—Participants were classified as nonsmokers, nondaily smokers, or daily smokers based on their responses to a baseline smoking history questionnaire.

Demographics.—A demographic questionnaire assessed participants’ sex (males coded 1, females coded 0) and age in years.

Data Analysis.

Generalized linear models (GzLMs) were used because the outcomes under investigation (craving, daily alcohol use) were not normally distributed. Cluster-robust standard errors were used in all models to account for the fact that observations were nested within individuals. We opted for population-averaged GzLMs over multilevel regression analyses

because we were not interested in cluster-specific inferences (McNeish, et al., 2017). GzLMs are nonlinear models requiring special practices for meaningful interpretation. (Long & Freese, 2014; Mize, 2019). Parameter estimates from GzLMs describe effects in a transformed metric that most often has no clear substantive interpretation. Exponentiated coefficients yield ratio statistics (e.g., odds or rate ratios) that are more useful effect size metrics but may still obscure the nature of underlying effects (Mize, 2019). Unlike linear models, effects of predictors are not constant across the predictor's natural range in GLMs. One consequence is that the regression coefficient for the product term of two predictors does not provide a sufficient test for an interactive effect involving those predictors. Instead, the direction and significance of any interactive effects depend on levels of all predictors in the model and can vary over the parameter space (McCabe, et al., 2020). To address these challenges, we conducted analyses in Stata 16 (StataCorp, College Station TX) and made use of the *margins* command to probe model effects (Long & Freese, 2014; Williams, 2012). This allowed us to: (1) plot model-generated predictions after transformation back to the natural metrics of the outcome variables, (2) supplement ratio statistics by presenting marginal predicted values in the natural outcome metric for selected levels of model covariates, (3) evaluate the magnitude and direction of marginal effects of key predictors in selected regions of the parameter space, and (4) evaluate interactive effects by explicitly testing whether the marginal effects of a focal predictor differed across the range of a second variable.

We first estimated a GzLM that predicted momentary alcohol craving from the main and interactive effects of contemporaneous negative affect and DMQ-R global coping motives. Negative affect was decomposed in two variables representing (a) the individual's mean rating across all non-drinking diary ratings, and (b) the deviation of each momentary ratings from the person-mean (i.e., centering within cluster; Enders & Tofighi, 2007). This decomposition separates between- and within-person differences in affect (Begg & Parides, 2003). Theoretically, within-person variations in negative affect are most relevant for examining dynamic relations among mood, coping motives, and craving. The model used a gamma distribution and a log link function. Gamma distributions are particularly useful in modeling skewed data with non-negative integers (Neal & Simons, 2007). Craving during nondrinking moments had a mode of 1 on the 1–5 rating scale and was positively skewed ($M = 1.5$, $SD = 1.0$, range = 1 to 5, skewness = 2.02). Additional covariates were DMQ-R enhancement, social, and conformity motives, age, sex, weekend, time of day, and smoking status. DMQ-R motives other than coping were covaried as each subscale may reflect a general level of motivation to drink; testing them simultaneously helps account for this general factor and may better isolate the effects specific to coping motives (e.g., Piasecki, et al., 2014). This model was limited to moments where participants were not currently drinking alcohol to remove any pharmacological and psychological effects of alcohol on momentary craving intensity. Similarly, the within- and between-person components of negative affect were calculated using ratings from only non-drinking diary records to exclude any acute effects of alcohol on mood from influencing this analysis of drinking antecedents.

Our main interest was in evaluating whether the effect of coping motives on craving varied across levels of within-person negative affect (and vice versa). Although a product term does

not provide a sufficient test of possible interactive effects in nonlinear GzLMs, including the product term in the model is valuable for accurately characterizing such effects (Mize, 2019). Accordingly, a product term involving coping motives and within-person negative affect was included in the model. We also included a product term involving between-person negative affect and coping motives to explore whether effects of coping motives might differ across individuals differing in mean levels of negative affect.

Next, a GzLM was estimated to predict the count of daily drinks from daily negative affect, coping motives, and covariates. A drink count of zero was reported on 65.4% of person-days, suggesting a model accounting for excess zeros was likely needed. Daily drink amounts ranging from 1 to 44 drinks (M = 1.78, SD = 5.2). Because very high drink counts are likely to reflect recording errors, days with drink counts higher than 15 (n = 135, 1.5% of person-days) were dropped prior to analysis. The *countfit* command in Stata 16 was used to select among various count model options. Results indicated very strong evidence for preferring a zero-inflated negative binomial (ZINB) model (BIC = 2916.104, AIC = 22712.439, average absolute difference between actual and predicted counts = .053) to a Poisson regression (BIC = 39136.639, AIC = 64172.281, average absolute difference = .886), a negative binomial regression model (BIC = 23612.297, AIC = 23506.953, average difference = .111), and a zero-inflated Poisson model (BIC = 24650.579; AIC = 24453.937, average difference = .144).

The ZINB model estimates two sets of model parameters within one model, one predicting count data and one for zeros (a logistic regression model predicting probability of being 0 vs. > 0). All data in the ZINB model were aggregated at the day level, summing together all momentary reports of drinking. Only negative affect scores from non-drinking moments were used to create aggregated day-level means to exclude any affective reactions to drinking from the analysis. Negative affect was again decomposed into between- and within-person variables by calculating (a) the person-mean over non-drinking records from all days and (b) the deviation of each person-day's nondrinking negative affect mean from the person-mean. All covariates from the craving model were also used in this model, except for time of day. Product terms involving coping motives and each component of negative affect were included in the model.

Finally, we conducted tests of moderated mediation evaluating whether (a) within-person level of negative affect indirectly influences drinking via within-person craving, and (b) whether this indirect effect differs over levels of coping motives and within-person negative affect. Mediation analysis involving GzLMs requires unique methods to account for the nonlinear nature of these models (Geldof, et al., 2018), and is further complicated when considering zero-inflated count outcomes, which require testing effects in both the zero and count portions of the model. O'Rourke and Vazquez (2019) presented methods for testing simple mediation effects with zero-inflated outcomes. This approach involved (1) fitting a linear regression analysis evaluating the association between the antecedent predictor and the mediator, and (2) estimating a zero-inflated count model in which the outcome is predicted from the antecedent variable and the mediator. Coefficients from the two models are multiplied to obtain estimates of the indirect effect, with separate estimates computed for the zero and count portions of the outcome. The first partial derivative of the loglinear

regression equation for the zero-inflated model is substituted for the *b* coefficient from a conventional mediation analysis, yielding conditional indirect effects that are a function of the levels of antecedent variable, the mediator, and covariates. O'Rourke and Vazquez (2019) recommend estimating indirect effects for representative or meaningful values of the antecedent at the mean of the mediator, computing separate estimates using coefficients from the zero and count models, and using bootstrap resampling methods for determining the confidence intervals around the indirect effect estimates.

We extended this approach to test a simple moderated mediation scenario in which the path from the antecedent (within-person negative affect) to the mediator (within-person craving) is moderated by another variable (coping motives). This involved first fitting a linear regression model in which daily within-person craving was predicted from daily within-person negative affect, coping motives, and their product. Covariates included sex, age, smoking status, weekend, enhancement, social, and conformity motives, between-person craving, and between-person negative affect. Next, we estimated a ZINB model predicting daily alcohol use from within-person craving and within-person negative affect and the same covariates used in the linear regression analysis. We computed conditional indirect effects for the zero and count portions of the model separately using the coefficients from the corresponding submodel. We estimated indirect effects across a range of values for within-person negative affect and coping motives, setting the covariates at their mean levels. For each estimate, bootstrap resampling (1,000 replications) was used to compute bias-corrected 95% confidence intervals. More computational details are provided in the online supplemental materials.

Results

Descriptive Statistics.

Participants recorded 39,774 assessments during non-drinking moments, spanning 8,501 total study days (*M* per person = 21.1) and including 3,091 drinking days. Table 1 presents descriptive statistics and correlations among key between-person variables.

Prediction of Momentary Craving.

Results from the GzLM predicting momentary alcohol craving are shown in Table 2. Predicted craving levels on the 1–5 rating scale are given in Table 3 for selected levels of each predictor, holding the remaining predictors at their means. Being male and younger in age were associated with elevated craving. Craving was higher on the weekends relative to weekdays and in the afternoon and night compared to mornings. Craving was elevated among participants endorsing higher coping motives, higher enhancement motives, and lower social motives. Higher person-mean levels of negative affect and within-person fluctuations in negative affect were significantly associated with craving.

Although the product term involving coping motives and within-person negative affect was not statistically significant, analyses of first differences in marginal effects supported the hypothesized interaction between these two variables. The left portion of Figure 1 depicts predicted levels of craving at high (+1 *SD*) and low (−1 *SD*) levels of coping motives across

the range of observed values of within-person negative affect. As the plot illustrates, average levels of craving were quite low overall in non-drinking moments. Within-person increases in negative affect were associated with modest elevations in craving, and this effect was slightly more pronounced among individuals endorsing higher coping motives.

The right portion of Figure 1 plots the average marginal effect of coping on craving at various levels within-person negative affect and their associated 95% confidence intervals. These effects represent the instantaneous rate of change (partial derivative) in craving associated with an infinitely small increase in coping motives at specific levels of within-person NA. They are averaged effects computed with all covariates as observed (Long & Freese, 2014). This plot illustrates that the marginal effect of coping increases at higher levels of negative affect.

The top portion of Table 4 presents formal tests of average marginal effects and first differences in marginal effects at selected levels of coping and within-person negative affect[1]. The marginal effect of coping motives on craving was significant at low, mean, and high levels of within-person negative affect. All pairwise comparisons of these marginal effects were statistically significant, indicating that the influence of coping is moderated by current affective state. A comparable analysis examining the marginal effects of within-person negative affect indicated that affect was significantly associated with craving and that the magnitude of this effect increased at higher levels of coping motives (Supplemental Table 1). Tests of marginal effects provided no support for interactive effects of coping motives and between-person negative affect (Table 4, bottom portion). An extended set of analyses indicated there was no evidence for a three-way interaction involving between-person affect, within-person affect, and coping motives (Supplemental Tables 2 and 3).

Prediction of Daily Consumption.

Results from the ZINB model predicting drinking are presented in Table 5. Marginal predicted drinking outcomes are given in Table 6 for selected levels of each predictor, holding the remaining predictors at their means. The binary submodel predicts whether the count outcome variable is zero. Odds of abstention decreased with age. Relative to nonsmokers, nondaily smokers had lower odds of abstention. Odds of non-drinking were lower on weekend days relative to weekdays. The product terms involving coping motives and negative affect were not significant. The top left panel of Figure 2 shows the average predicted probabilities of reporting zero drinks over levels of within-person negative affect for drinkers at high and low levels of coping motives. The bottom left panel depicts averaged marginal effects of coping at the same levels of negative affect. Both plots suggest the effect of coping was consistent over negative affect. Table 7 presents tests of marginal effects. Tests of first differences of coping over within-person negative affect (and vice versa, Supplemental Table 4) provide no support for interactive effects. There was no indication of interactions involving between-person negative affect and coping (Table 7, Supplemental Table 4).

[1]The second-order cross-partial derivative would provide a more comprehensive test of interaction effects involving these continuous predictors (McCabe, et al., 2020). However, we are not able to identify software that produces a test of this quantity for the types of models conducted here.

Results from the count portion of the ZINB model indicated that males reported higher drink totals than females. Drinking quantity decreased with age, was higher on the weekend, and increased at higher levels of enhancement motives. Neither product term involving coping and negative affect was statistically significant. Plots of predicted drink count at high and low coping motives (Figure 2, top right) and marginal effects of coping motives (Figure 2, bottom right) indicate that the effect of coping on drink count was fairly consistent over degrees of within-person negative affect. Formal tests of first differences of coping over within-person negative affect (Table 7; and vice versa, Supplemental Table 4) did not reveal any interactive effects. Similarly, there was no evidence for interactive effects of between-person negative affect and coping motives (Table 7, Supplemental Table 4).

Conditional Indirect Effects.

In a linear regression model predicting within-person craving, the interaction between coping motives and within-person negative affect was significant ($B = 0.071$, 95% CI = 0.021, 0.121, $p = .005$) and indicated that craving increased more strongly when mood worsened among drinkers with higher vs. lower coping motives (Supplemental Figure 1). The main effect of within-person negative affect on within-person craving was not significant ($B = -0.018$, 95% CI = −0.136, 0.101, $p = .771$). In a ZINB model predicting daily drinking, within-person craving was associated with decreased odds of abstention (odds ratio [OR] = 0.50, 95% CI = 0.43, 0.58, $p < .001$) and higher drink count (rate ratio [RR] = 1.13, 95% CI = 1.07, 1.18, $p < .001$). Within-person negative affect was associated with increased odds of abstention (OR = 1.41, 95% CI = 1.25, 1.59, $p < .001$) and decreased drink counts (RR = 0.88, 95% CI = 0.82, 0.94, $p < .001$) after accounting for the mediator and covariates. Full results from these models are provided in Supplemental Tables 5 and 6.

Figure 3 depicts estimates of conditional indirect effects of within-person negative affect on drinking via craving along with bootstrapped confidence intervals at varying combinations of within-person negative affect and coping motives. All estimated indirect effects were statistically significant, as indicated by the fact that their confidence intervals did not include zero.

Indirect effects in the zero portion of the model were negative, indicating that the path from negative affect through increased craving tended to decrease the likelihood of abstention. This effect was more pronounced among drinkers reporting stronger coping motives. At a given level of coping motives, higher levels of within-person negative affect were associated with somewhat stronger indirect effects. In the count portion of the model, indirect effects were positive, indicating that increasing within-person negative affect tended to increase amount consumed via increases in craving intensity. These effects were larger among drinkers reporting stronger coping motives. At a given level of coping, increases in within-person negative affect were associated with slight decreases in the indirect effect estimate.

Exploratory Analyses.

We conducted sensitivity analyses in which between-person negative affect was represented using the person-mean over *all* records (i.e., drinking and non-drinking moments) and within-person negative affect was represented as deviations of momentary ratings around

this adjusted mean. Thus, the within-person negative affect variable in these analyses effectively contrasts current affect with a mean that encompasses a broader set of experiences, including those associated with alcohol use. Results were very similar to of the primary analyses (Supplemental Tables 7–12; Supplemental Figures 2–4).

A final series of analyses explored the specificity of the interactive effects of coping and within-person negative affect in the prediction of craving. The basic craving model was expanded to include positive affect and include product terms involving each drinking motive and between- and within-person components of both positive and negative affect (Supplemental Tables 13 and 14, Supplemental Figure 5). Results indicated that coping motives interacted with within-person positive affect in almost exactly the same fashion as with negative affect. Compared to coping motives, enhancement motives had smaller, positive and significant marginal effects on craving. Like coping, enhancement motives moderated effects of both within-person positive and negative affect, although the effect was marginally larger for positive affect ($p = .088$; Supplemental Table 14). Higher social motives were associated with lower craving, particularly at high levels of within-person negative affect. Conformity motives did not have significant effects on craving levels.

Discussion

Craving is an appealing outcome measure when investigating drinking motives because (a) it represents an approach-oriented drug motivational state that is conceptually intermediate between triggering environmental stimuli and alcohol self-administration, and (b) it may be a more sensitive response channel than drinking behavior for detecting interaction effects of particular affective states and their theoretically matched drinking motives.

The central hypothesis of this research was that, compared to their peers, drinkers holding stronger coping motives would report heightened craving for alcohol when experiencing negative mood states. This hypothesis was borne out by our analysis. Coping motives did moderate the association between negative affect and craving, such that coping-motived drinkers showed higher desire to drink in periods of increased distress. In contrast, we failed to find interactive effects of coping motives and negative affect when predicting drinking outcomes.

A moderated mediation analysis indicated that (a) the direct effect of increases in negative affect was to *decrease* the likelihood of drinking and *reduce* the expected number of drinks consumed, (b) increases in negative mood were associated with elevated levels of alcohol craving, which in turn were associated with increased odds of drinking and higher drink counts, and (c) this indirect drinking-promotive path from negative affect via craving was more pronounced among drinkers who endorsed strong coping motives. These findings suggest negative affect has bidirectional influences on drinking and may help explain why the complex and contradictory findings from diary studies of mood, coping motives, and alcohol use (Armeli et al., 2010; Carney et al., 2000; Grant et al., 2009; Hussong et al., 2005; Littlefield, et al., 2012; Mohr et al., 2005; O'Hara, et al., 2014; Park, et al., 2004; Todd et al., 2003; 2005). Elevated negative affect might tend to inhibit drinking through processes such as social withdrawal or the need to cope with acute stressors and problems.

At the same time, negative mood is one of many possible contributory causes of craving for alcohol, particularly for drinkers high in coping motives. These two opposing sets of motivational effects may cancel one another out in many circumstances. Future research might explore more systematically factors affecting the balance of drinking-promoting and drinking-inhibiting effects of negative mood.

Exploratory analyses revealed that craving was influenced by a number of combinations of affective states and drinking motives. Craving was elevated at higher levels of both positive and negative affect. Coping motives moderated effects of positive and negative affect in a similar fashion, suggesting coping effects depend more on emotional intensity than valence. Enhancement and coping, the two internally-focused motives, had broadly similar moderating effects on the affect-craving association. In contrast, higher social motives were associated with decreased craving at higher levels of within-person affect and conformity motives had little association with craving. Future work is needed to investigate how craving relates to affect in drinkers holding distinct configurations of motives. Additionally, more work is necessary to investigate the array of potential conditional indirect effects of mood states on drinking operating through craving and their potential moderation by diverse drinking motives.

Mean levels of craving during non-drinking moments were low overall and the combined effects of elevated within-person negative affect and high coping motives still produced rather modest levels of craving intensity (viz., a marginal mean of ~ 2 on a 1–5 rating scale; Figure 1). Thus, the craving experiences studied here seem to represent mild stirrings or impulses to drink rather than overwhelming and irresistible urges. However, both between- and within-person levels of craving in non-drinking moments were associated with the occurrence and extent of same-day drinking (Supplemental Tables 6 and 12), suggesting these low-intensity experiences are worth taking seriously. Future research linking motives and craving might benefit from development of self-report or implicit measures that better resolve the low end of the craving intensity spectrum.

Although not the focus of this research, the findings add to a large body of evidence (including prior analyses of this sample; Piasecki, et al., 2014) linking higher enhancement motives with heavier alcohol consumption (Cooper, et al., 2015; Kuntsche & Cooper, 2010). Enhancement motives were positively correlated with the total number of drinks consumed during the EMA period (Table 1) and predictive of heavier episodic alcohol consumption (Table 5). The current study extends this literature by demonstrating that enhancement motives are associated with elevated levels of alcohol craving between drinking episodes. Further, enhancement interacts with affect such that drinkers holding stronger enhancement motives report larger increases in momentary craving when experience higher levels of within-person negative and positive affect (Supplemental Table 14, Supplemental Figure 5).

The present study must be considered in light of limitations. First, enrollment in the current study was limited to individuals who drank at least weekly and cigarette smokers were oversampled by design (Piasecki, et al., 2011). The sample skewed toward young adults. It is possible that findings would not generalize to dissimilar samples. The diary assessment used a short, two-item measure of negative affect. More robust interactive effects of coping

motives and negative mood might have emerged if we had used a broader inventory of dysphoric states.

We used a global measure of dispositional drinking motives. Other research has demonstrated that there is substantial within-person variation in coping motives for drinking over time and situations (e.g., Arbeau, et al., 2011; O'Donnell et al., 2019; O'Hara et al., 2014). Future research might investigate how both trait and state measures of coping motives dynamically relate to fluctuations in negative affect and craving.

The current study was motivated by the intuition that prediction of alcohol use outcomes may be hampered by factors such as constraints on access, habit, and motives to limit or abstain drinking. It is important to note that these factors were not directly measured here, and the current findings do not empirically establish the veracity of this motivating surmise. Future studies might incorporate measures of situational constraints on alcohol use and motives for limiting or abstaining from drinking. Some theoretical models posit that negative affect and constraints on drug self-administration play important roles in the genesis and intensification of craving (e.g., Baker, et al., 2004; Tiffany, 1990). Thus, diary studies assessing these variables could permit investigation of a rich set of hypotheses drawing from diverse theories of drug motivation.

Notwithstanding these limitations, this study extends the literature on dispositional coping motives for drinking. The findings demonstrate that coping motives are associated with elevated craving for alcohol between drinking episodes and suggest that coping motives synergize with fluctuations in negative mood states to promote alcohol craving. Progress in understanding the mechanisms through which drinking motives contribute to problematic drinking outcomes may be accelerated by incorporating analyses focused on craving states in addition to drinking behavior per se in daily diary studies. Clinically, the findings suggest the hypothesis that pharmacologic and behavioral interventions focused on decreasing alcohol craving or interrupting the progression from craving to alcohol use may be especially helpful for coping-motived drinkers.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Public Health Significance Statement:

This study found that increases in negative mood are associated with increases alcohol craving, particularly among drinkers who report stronger dispositional motives to drink to cope with negative moods. In turn, these increases in craving predicted subsequent alcohol use. Craving may be a useful outcome for investigating the interplay among distal drinking motives, situational instigators, and alcohol use.

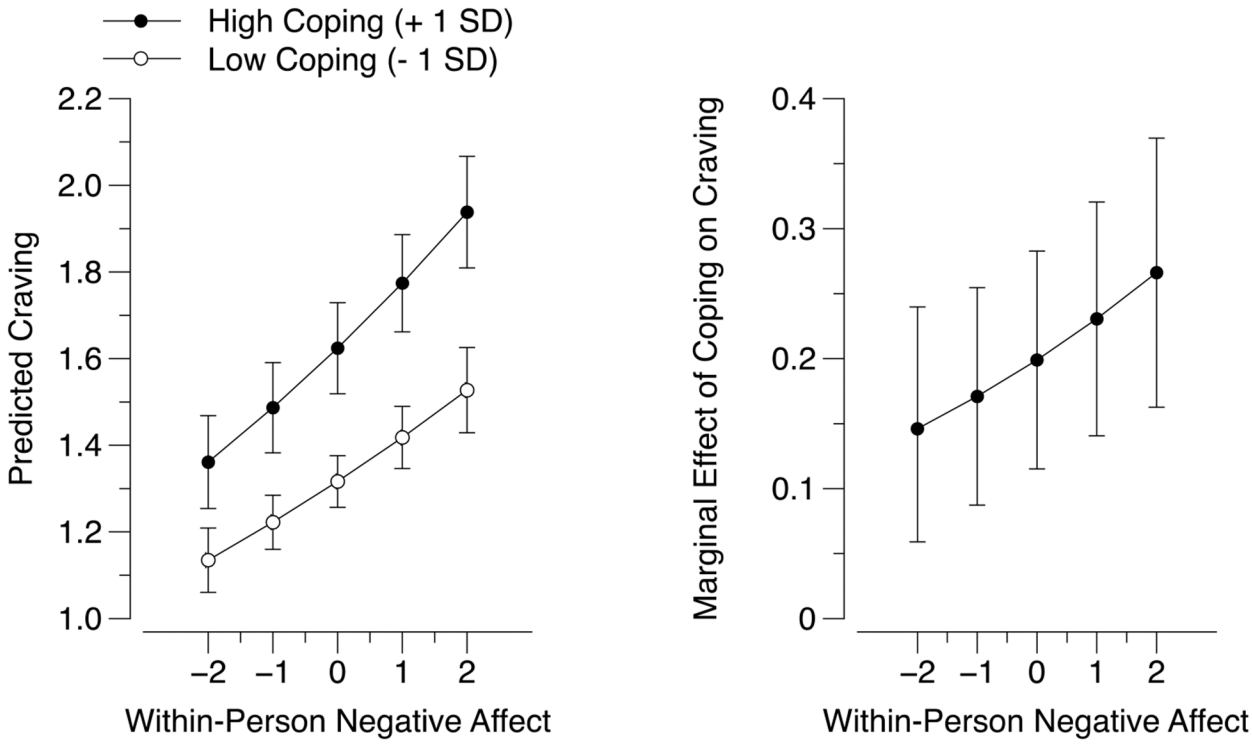

Figure 1:

(*Left panel*) Model estimated marginal means and associated 95% confidence intervals illustrating the interaction between coping motives and within-person negative affect in the prediction of momentary alcohol craving in diary assessments recorded in non-drinking moments. Estimated means are plotted across the range of observed values of within-person negative affect at High (+ 1*SD*) and Low (−1 *SD*) levels of coping motives and at the means of all other covariates in the model. (*Right panel*) Averaged instantaneous marginal effects of DMQ-R coping motives on craving and associated 95% confidence intervals across levels of within-person negative affect.

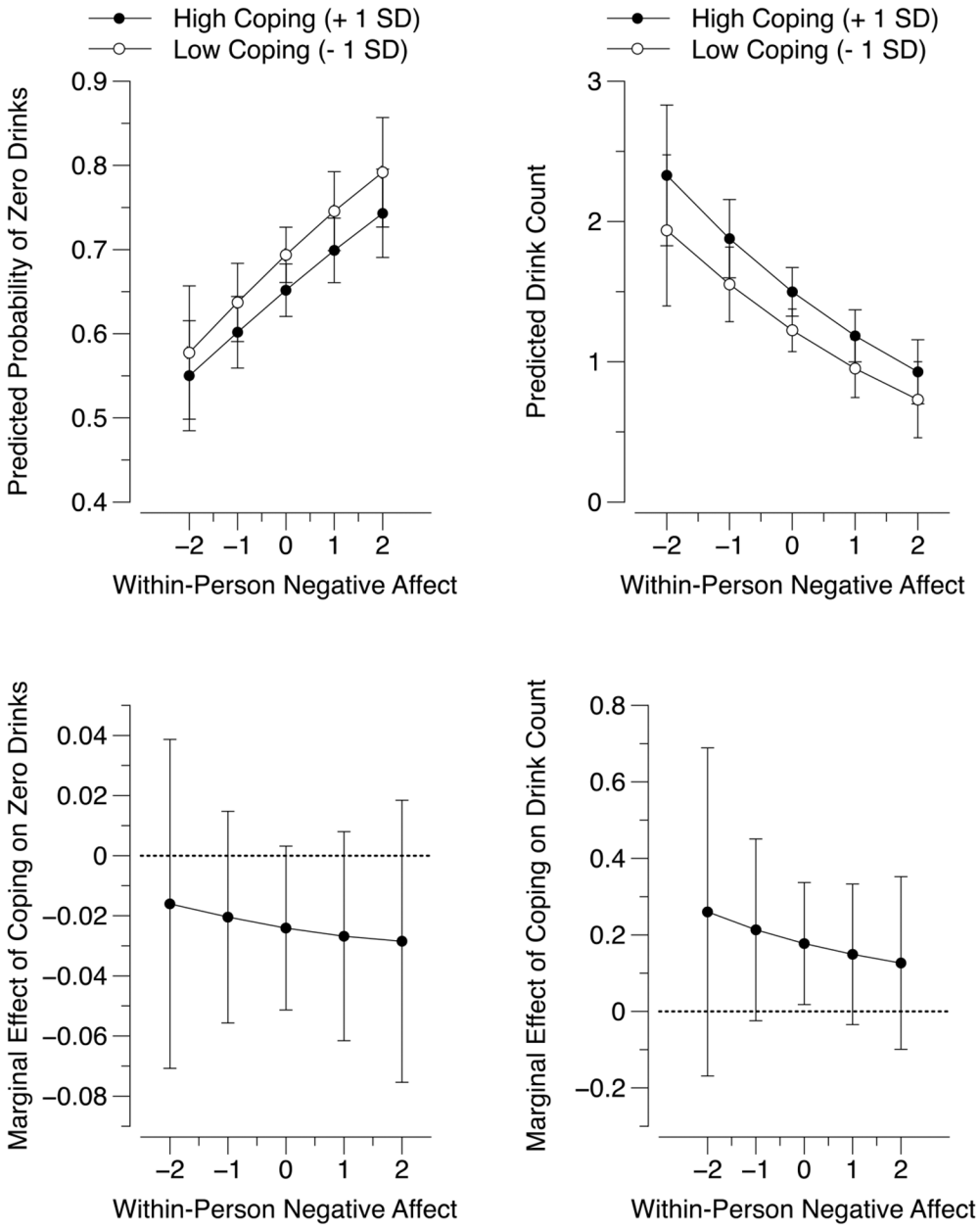

Figure 2:

(*Top left panel*) Model estimated probability of reporting zero drinks and associated 95% confidence intervals at High (+1 *SD*) and Low (−1 *SD*) levels of coping motives as a function of within-person negative affect and at the means of all other covariates in the model. (*Bottom left panel*) Averaged instantaneous marginal effects of DMQ-R coping motives on probability of reporting zero drinks and associated 95% confidence intervals across levels of within-person negative affect. (*Top right panel*) Model estimated marginal drink count and associated 95% confidence intervals at High (+1 *SD*) and Low (−1 *SD*) levels of coping motives as a function of within-person negative affect and at the means of all other covariates in the model. (*Bottom right panel*) Averaged instantaneous marginal

effects of DMQ-R coping motives and associated 95% confidence intervals on drink count across levels of within-person negative affect.

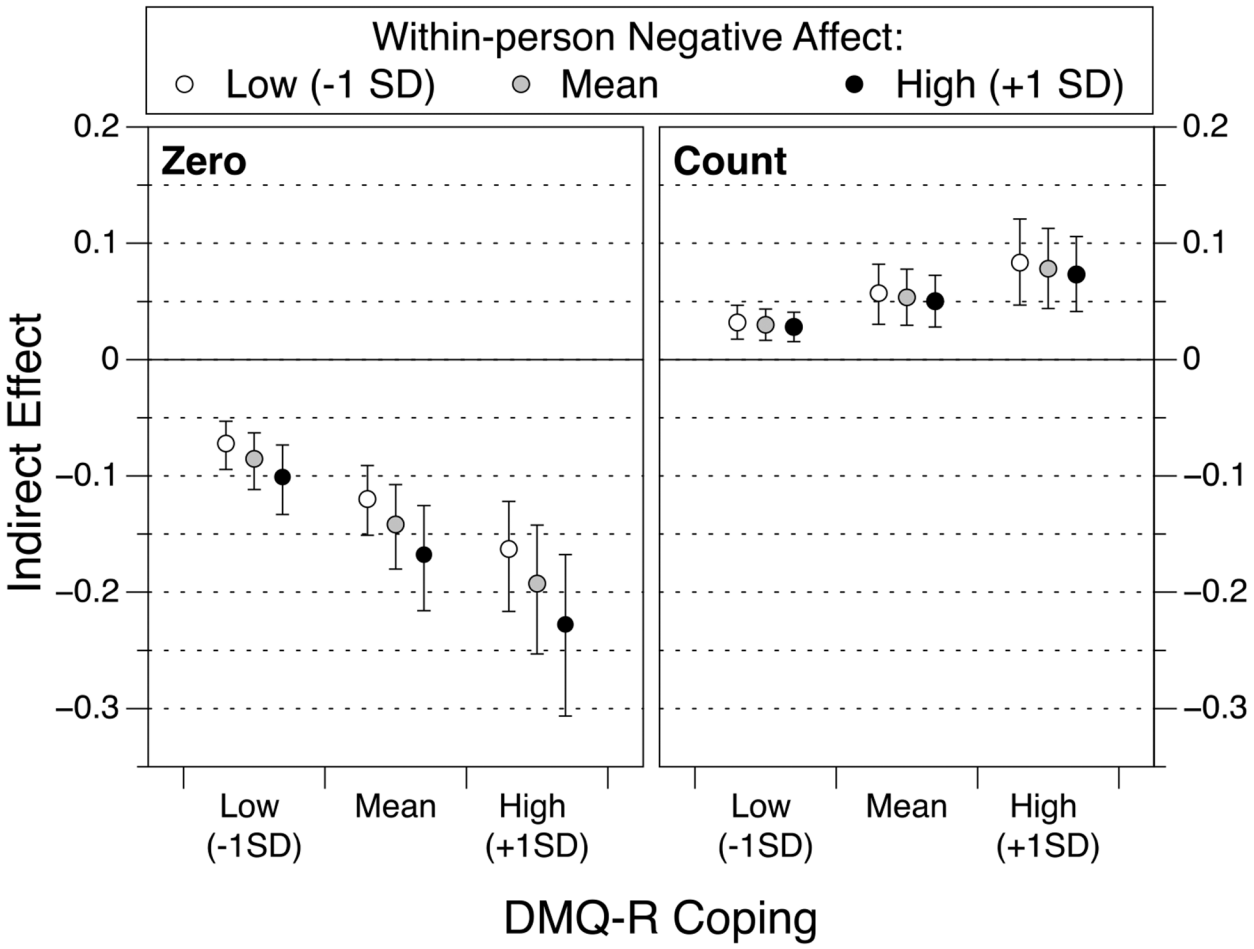

Figure 3.
Conditional indirect effects of within-person negative affect on drinking outcomes through craving and associated bias-corrected 95% confidence intervals.

Table 1.

Descriptive statistics and zero-order correlations among selected person-level variables.

Variable	M	SD	1	2	3	4	5	6	7	8
1. Age	23.35	7.21	--							
2. Coping	2.10	0.78	.02	--						
3. Enhancement	3.37	0.94	−.26***	28***	--					
4. Conformity	1.56	0.70	−.09	33***	25***	--				
5. Social	3.67	0.92	−.31***	.26***	.61***	.40***	--			
6. Number of Drinking Days	7.29	4.38	23***	.13**	.10*	−.08	−.03	--		
7. Total Drinks	37.45	31.92	−.09	.12*	32***	.01	.16**	.66**	--	
8. Between-person Negative Affect[a]	1.70	0.59	.05	37***	.06	.15**	.09	−.002	−.07	--
9. Between-person Craving[a]	1.52	0.59	− 14**	35***	23***	.10*	.09	20***	28***	32***

*$p < .05$,

**$p < .01$,

***$p < .001$;

[a]Means calculated over non-drinking moments only.

Table 2.

Results from generalized linear model predicting momentary alcohol craving during non-drinking moments.

Predictor	RR	95% CI	*P*
Sex	1.17	1.10, 1.24	<.001
Age	0.99	0.988, 0.996	<.001
Smoking Status			
Nonsmoker (Ref)	1.00	--	--
Daily	1.04	0.97, 1.12	.263
Nondaily	1.03	0.94, 1.13	.561
Time of Day			
Morning (Ref)	1.00	--	--
Afternoon	1.18	1.15, 1.20	<.001
Night	1.30	1.26, 1.33	<.001
Weekend	1.14	1.12, 1.16	<.001
Coping	1.18	1.02, 1.38	.029
Enhancement	1.06	1.01, 1.11	.009
Conformity	0.99	0.94, 1.03	.596
Social	0.94	0.89, 0.98	.008
Between-person Negative Affect	1.21	1.01, 1.44	.038
Within-person Negative Affect	1.06	1.02, 1.11	.003
Coping × Between-person Negative Affect	0.98	0.90, 1.06	.618
Coping × Within-person Negative Affect	1.01	0.99, 1.03	.261

Note: RR = rate ratio.

Table 3.

Marginal craving means for selected levels of covariates, with the remaining predictors held at their means.

Predictor	Predicted Craving	95% CI
Sex		
Male	1.58	1.50, 1.66
Female	1.35	1.29, 1.41
Age		
20	1.51	1.45, 1.57
30	1.39	1.34, 1.45
40	1.29	1.20, 1.38
50	1.19	1.07, 1.32
Smoking Status		
Nonsmoker	1.42	1.35, 1.50
Daily	1.48	1.41, 1.56
Nondaily	1.46	1.35, 1.58
Time of Day		
Morning	1.25	1.21, 1.29
Afternoon	1.47	1.41, 1.53
Night	1.62	1.56, 1.68
Day		
Weekday	1.40	1.35, 1.46
Weekend	1.60	1.54, 1.66
Coping		
−1 *SD*	1.32	1.26, 1.38
M	1.46	1.41, 1.51
+1 *SD*	1.62	1.52, 1.73
Enhancement		
−1 *SD*	1.39	1.31, 1.47
M	1.47	1.41, 1.52
+1 *SD*	1.55	1.47, 1.63
Conformity		
−1 *SD*	1.47	1.40, 1.54
M	1.46	1.41, 1.51
+1 *SD*	1.45	1.38, 1.51
Social		
−1 *SD*	1.55	1.46, 1.64
M	1.46	1.40, 1.51
+1 *SD*	1.37	1.29, 1.45
Between-person Negative Affect		
−1 *SD*	1.34	1.28, 1.41
M	1.47	1.41, 1.52
+1 *SD*	1.60	1.51, 1.68

Predictor	Predicted Craving	95% CI
Within-person Negative Affect		
−1 *SD*	1.38	1.33, 1.43
M	1.46	1.41, 1.51
+1 *SD*	1.54	1.48, 1.60

Table 4.

Tests of averaged marginal effects probing for interactive effects involving negative mood, coping motives, and craving.

Estimated Effect	Average Marginal Effect	95% CI	*P*
Coping × Within-person Negative Affect			
DMQ-R Coping at:			
Low WP Negative Affect (−1*SD*)	0.180	0.097, 0.263	<.001
Mean WP Negative Affect	0.199	0.115, 0.283	<.001
High WP Negative Affect (+1*SD*)	0.220	0.133,0.307	<.001
First Differences:			
Mean – Low	0.019	0.005, 0.034	.009
High – Mean	0.021	0.005, 0.037	.011
High – Low	0.040	0.010, 0.070	.010
Coping × Between-person Negative Affect			
DMQ-R Coping at:			
Low BP Negative Affect (−1*SD*)	0.202	0.090, 0.313	<.001
Mean BP Negative Affect	0.201	0.117, 0.286	<.001
High BP Negative Affect (+1*SD*)	0.199	0.089, 0.310	<.001
First Differences:			
Mean - Low	−0.0002	−0.066, 0.066	.977
High - Mean	−0.002	−0.080, 0.076	.963
High - Low	−0.002	−0.146, 0.142	.977

Note: WP = within-person; BP = between-person.

Table 5:

Results from zero-inflated negative binomial regression model predicting daily drinking

	Binary Submodel: Zero Drink			Count Submodel: Total Drinks		
Predictor	**OR**	**95% CI**	***p***	**RR**	**95% CI**	***p***
Sex	0.84	0.69, 1.03	.101	1.25	1.11, 1.41	<.001
Age	0.95	0.92, 0.98	.001	0.98	0.97, 0.99	<.001
Smoking Status						
Nonsmoker (Ref)	---	---	---	---	---	---
Nondaily smoker	0.77	0.59, 0.99	.048	0.98	0.84, 1.14	.772
Daily smoker	0.81	0.65, 1.02	.073	1.10	0.96, 1.25	.181
Weekend	0.31	0.27, 0.36	<.001	1.29	1.20, 1.38	<.001
Conformity	1.13	0.94, 1.36	.200	0.96	0.86, 1.07	.439
Social	1.06	0.92, 1.22	.393	0.99	0.91, 1.07	.774
Enhancement	0.91	0.79, 1.05	.182	1.22	1.13, 1.32	<.001
Coping	1.16	0.77, 1.73	.480	1.20	0.95, 1.51	.488
BP Negative Affect	1.45	0.87, 2.43	.153	1.11	0.82, 1.51	.488
WP Negative Affect	1.34	0.97, 1.87	.079	0.94	0.77, 1.15	.536
Coping × BP Negative Affect	0.86	0.69, 1.07	.172	0.93	0.82, 1.05	.234
Coping × WP Negative Affect	0.97	0.85, 1.10	.618	0.98	0.91, 1.06	.665

Note: BP = between-person, WP = within-person, OR = odds ratio, RR = rate ratio. The dependent measure in the binary submodel is a nondrinking day, represented by a value of zero. Thus, model coefficients should be interpreted as indexing the association between the predictor and abstention from alcohol.

Table 6.

Marginal probabilities of reporting zero drinks and predicted drink counts for selected levels of covariates, with the remaining predictors held at their means.

Predictor	Probability of Zero Drinks (95% Cl)	Marginal Drink Count, (95% Cl)
Sex		
Male	.645 (.614, .677)	1.67 (1.50, 1.85)
Female	.700 (.673, .726)	1.10 (0.98, 1.22)
Age		
20	.704 (.682, .726)	1.30 (1.18, 1.42)
30	.613 (.561, .665)	1.43 (1.25, 1.61)
40	.534 (.440, .628)	1.46 (1.17, 1.76)
50	.481 (.374, .588)	1.40 (1.04, 1.77)
Smoking Status		
Nonsmoker	.703 (.676, .731)	1.19 (1.06, 1.33)
Daily	.657 (.622, .692)	1.49 (1.30, 1.67)
Nondaily	.652 (.603, .702)	1.36 (1.12, 1.63)
Day		
Weekday	.737 (.716, .758)	1.03 (0.94, 1.13)
Weekend	.477 (.446, .507)	2.52 (2.33,2.72)
Coping		
−1 *SD*	.694 (.661, .727)	1.22 (1.07, 1.37)
M	.673 (.651, .695)	1.35 (1.25, 1.46)
+1 *SD*	.652 (.621, .683)	1.50 (1.32, 1.67)
Enhancement		
−1 *SD*	.704 (.673, .735)	1.06 (0.92, 1.21)
M	.673 (.651, .695)	1.36 (1.25, 1.46)
+1 *SD*	.642 (.605, .680)	1.73 (1.52, 1.94)
Conformity		
−1 *SD*	.658 (.630, .686)	1.44 (1.30, 1.58)
M	.673 (.652, .695)	1.35 (1.25, 1.46)
+1 *SD*	.692 (.657, .726)	1.25 (1.08, 1.41)
Social		
−1 *SD*	.661 (.626, .696)	1.42 (1.22, 1.61)
M	.673 (.651, .695)	1.35 (1.25, 1.46)
+1 *SD*	.685 (.651, .719)	1.29 (1.12, 1.47)
Between-person Negative Affect		
−1 *SD*	.665 (.635, .695)	1.42 (1.27, 1.57)
M	.673 (.652, .695)	1.35 (1.25, 1.46)
+1 *SD*	.681 (.651, .711)	1.29 (1.14, 1.44)
Within-person Negative Affect		
−1 *SD*	.647 (.623, .672)	1.52 (1.39, 1.65)
M	.673 (.651, .695)	1.36 (1.25, 1.46)

Predictor	Probability of Zero Drinks (95% CI)	Marginal Drink Count, (95% CI)
+1 *SD*	.698 (.673, .723)	1.20 (1.09, 1.32)

Table 7.

Tests of averaged marginal effects probing for interactive effects involving negative mood, coping motives, and daily drinking.

Estimated Effect	Marginal Effect, Zero Drinks	95% CI	*P*	Marginal Effect, Drink Count	95% CI	*P*
Coping* × *Within-person Negative Affect						
DMQ-R Coping at:						
Low WP Negative Affect (−1*SD*)	−0.022	−0.051,0.007	.130	0.194	0.013,0.375	.036
Mean WP Negative Affect	−0.024	−0.051,0.003	.083	0.177	0.018, 0.337	.029
High WP Negative Affect (+1*SD*)	−0.026	−.055, 0.004	.091	0.163	−0.016, 0.327	.052
First Differences						
Mean – Low	−0.002	−0.013,0.010	.773	−0.016	−0.090, 0.057	.662
High – Mean	−0.001	−0.012, 0.009	.790	−0.015	−0.076, 0.047	.643
High – Low	−0.003	−0.025, 0.019	.781	−0.031	−0.167, 0.104	.653
Coping* × *Between-person Negative Affect						
DMQ-R Coping at:						
Low BP Negative Affect (−1*SD*)	−0.011	−0.048, 0.025	.534	0.182	−0.054, 0.418	.131
Mean BP Negative Affect	−0.025	−0.052, 0.003	.076	0.180	0.021,0.339	.027
High BP Negative Affect (+1*SD*)	−0.037	−0.071,−0.003	.031	0.179	0.008, 0.350	.041
First Differences						
Mean - Low	−0.013	−0.036, 0.009	.253	−0.002	−0.137, 0.133	.978
High - Mean	−0.013	−0.034, 0.009	.255	−0.001	−0.124, 0.122	.985
High - Low	−0.026	−0.070, 0.018	.254	0.003	−0.261,0.255	.981

Note: WP = within-person; BP = between-person.