Published in final edited form as:

J Abnorm Psychol. 2014 August ; 123(3): 676–694. doi:10.1037/a0036926.

The Many Faces of Affect: A Multilevel Model of Drinking Frequency/Quantity and Alcohol Dependence Symptoms Among Young Adults

Jeffrey S. Simons,

Department of Psychology, The University of South Dakota

Thomas A. Wills, and

Epidemiology Program, University of Hawaii Cancer Center

Dan J. Neal

Department of Psychology, Kent State University

Abstract

This research tested a multilevel structural equation model of associations between 3 aspects of affective functioning (state affect, trait affect, and affective lability) and 3 alcohol outcomes (likelihood of drinking, quantity on drinking days, and dependence symptoms) in a sample of 263 college students. Participants provided 49 days of experience sampling data over 1.3 years in a longitudinal burst design. Within-person results: At the daily level, positive affect was directly associated with greater likelihood and quantity of alcohol consumption. Daily negative affect was directly associated with higher consumption on drinking days and with higher dependence symptoms. Between-person direct effects: Affect lability was associated with higher trait negative, but not positive, affect. Trait positive affect was inversely associated with the proportion of drinking days, whereas negative affectivity predicted a greater proportion of drinking days. Affect lability exhibited a direct association with dependence symptoms. Between-person indirect effects: Trait positive affect was associated with fewer dependence symptoms via proportion of drinking days. Trait negative affect was associated with greater dependence symptoms via proportion of drinking days. The results distinguish relations of positive and negative affect to likelihood versus amount of drinking and state versus trait drinking outcomes, and highlight the importance of affect variability for predicting alcohol dependence symptoms.

Keywords

affective lability; alcohol dependence; emotional regulation

Drinking and associated problems are highly prevalent on college campuses in the United States and other countries. Approximately 43% of U.S. college students engage in heavy episodic drinking (Substance Abuse and Mental Health Service Administration, [SAMHSA], 2010). For many, drinking can be a normative behavior, integrated into

Correspondence concerning this article should be addressed to Jeffrey S. Simons, Department of Psychology, The University of South Dakota, Vermillion, SD 57069. jsimons@usd.edu.

socializing and celebratory functions (e.g., Mohr et al., 2005; Neighbors et al., 2007; Schulenberg & Maggs, 2002). However, heavy alcohol consumption is associated with psychosocial problems (Neal & Fromme, 2007; Read, Merrill, Kahler, & Strong, 2007), and alcohol use disorders are relatively common among college students, with 17% meeting criteria for abuse or dependence (SAMHSA, 2011).

Although some level of alcohol consumption is necessary for the occurrence of alcohol-related problems, there is considerable variability in the extent to which individuals experience negative consequences and whether heavy drinking is a time-limited phenomenon or represents the beginning of ongoing problems with alcohol (Jackson, Sher, & Park, 2005; Jochman, Fromme, & Scheier, 2010; Neal & Fromme, 2007). Alcohol problems can be influenced both by background variables and by contextual variables (Jackson, O'Neill, & Sher, 2006; Simons, Gaher, Oliver, Bush, & Palmer, 2005b). Moreover, drinking and associated problems vary both within-person across time, as well as between persons. Recent reviews have noted that many of the findings about processes in alcohol problems are derived from between-person designs, but this does not provide assurance that such processes operate on a daily basis, where much of the variance in drinking occurs (Kassel et al., 2010; Mohr, Armeli, Tennen, & Todd, 2010). Indeed, findings from between- and within-person studies may vary (Curran & Bauer, 2011; Mohr et al., 2010), and both are important for understanding the factors contributing to frequency/quantity of drinking and associated problems.

Currently there is a theoretical and methodological gap in the literature in that few studies have tested theoretical propositions about both within- and between-person associations of affect-regulation constructs with young adult alcohol consumption and dependence symptoms. As a result, it is difficult to integrate the many disparate findings in the literature as differences in levels of analysis (within- vs. between- person), outcomes (frequency, quantity, and dependence symptoms), and samples are confounded across studies. Addressing this gap in the literature was the goal of the present study. In the following sections we discuss the role of state and trait affective variables in drinking and associated problems among young adults. We discuss advantages for utilizing multilevel structural equation modeling (MSEM) to derive latent state (i.e., daily/within-person) and trait (i.e., dispositional/between-person) estimates from experience sampling data. MSEM accounts for measurement error in the derived latent trait variables, can reduce bias in the estimates of between-subjects effects, and allows for estimating indirect effects among variables assessed at different levels of measurement (Lüdtke et al., 2008; Muthén & Muthén, 2012; Preacher, Zhang, & Zyphur, 2011; Preacher, Zyphur, & Zhang, 2010). Finally, we summarize the hypotheses of the research.

Affective Models of Alcohol Use

Affect regulation is central to several theoretical models of substance use and associated problems. Functional models posit that individuals drink alcohol in part because of its actual or expected effects for decreasing negative affect and for increasing positive affect (Cooper, 1994; Cox & Klinger, 1988; Wills & Shiffman, 1985). However, data on associations between affect and substance use have been complex. Understanding associations between affect and alcohol use requires consideration of multiple aspects of emotional functioning and drinking outcomes, and distinctions between within-person processes (i.e., state or event-level effects) and between-person associations (i.e., trait or global effects). In the following sections, we discuss research on associations between drinking outcomes and state and trait affect and affect lability.

Negative Affect: Within- and Between-Person Associations

Although negative reinforcement is ubiquitous in etiological models of substance use disorder, research linking negative affectivity to drinking behavior among young adults has produced mixed results (Kassel & Veilleux, 2010). Colder, Chassin, Lee, and Villalta (2010) note that some between-subjects studies have shown prospective effects for depression but the literature includes null results, and at the between-subjects level there are studies of young adults where negative affect and/or coping motives exhibit weak or insignificant associations with drinking (Mezquita, Stewart, & Ruiperez, 2010; Simons, Gaher, Correia, Hansen, & Christopher, 2005a).

Studies examining within-person associations have shown some associations between negative affect and drinking among young adults (e.g., Park, Armeli, & Tennen, 2004) but tend to show fairly modest effects (Armeli, Todd, Conner, & Tennen, 2008; Hussong, 2007; Simons, Dvorak, Batien, & Wray, 2010; Simons et al., 2005b), which has led to an increased interest in identifying potential moderators and examining time lags between negative affect and subsequent drinking (Armeli et al., 2008; Hussong, 2007; Simons et al., 2010). To date, there is a strong theoretical rationale for the hypothesis that negative affect and alcohol consumption should be linked at the state level and, by extension, that individuals who characteristically experience more negative affect should be at increased risk for higher rates of use. However, the empirical support for these propositions is less robust.

Factors contributing to the frequency of drinking, the amount consumed on drinking occasions, and development of dependence symptoms can vary (Glantz, Weinberg, Miner, & Colliver, 1999). Negative affect may be related to loss of control over drinking through multiple mechanisms. For example, it may signal symptoms of withdrawal or promote uncontrolled high-level consumption via its effect on biasing incentive values, drinking response, or reducing access to declarative knowledge and controlled processing (Baker, Piper, McCarthy, Majeskie, & Fiore, 2004). Hence, negative affect may exhibit associations with symptoms of dependence over and above effects of alcohol consumption. We hypothesized that negative affect would predominantly exhibit associations with problematic consumption patterns rather than more normative use in this population (Simons et al., 2005b), which would be reflected by direct associations with dependence symptoms at both the within- and between- person level.

Positive Affect: Within- and Between-Person Associations

Trait positive affect is an aspect of subjective well-being, and between-subjects studies have shown inverse associations of trait positive affect with drinking in adolescent samples (Colder & Chassin, 1997; Wills, Sandy, Shinar, & Yaeger, 1999). Similarly, *reward-deficiency models* suggest that persons who are less responsive to natural rewards (e.g., characterized by relatively lower positive affect) are at increased risk for substance abuse for affect-enhancement purposes (Bowirrat & Oscar-Berman, 2005; Yacubian & Buchel, 2009). However, positive mood is also associated with sociability and enhancement motives, and thus may exhibit positive associations with alcohol use in contexts where social drinking is a predominant pattern (Mezquita et al., 2010; Simons et al., 2005a).

In contrast to between-person findings, studies of within-person associations between positive affect and alcohol consumption among young adults demonstrate a consistent positive association between increases in positive arousal and subsequent alcohol consumption (Armeli et al., 2008; Colder et al., 2010; Simons et al., 2010). A recent review has suggested that associations between positive affect and drinking are discordant at the within- and between-person levels, with state positive affect predicting acute increases in drinking whereas trait positive affect is associated with consistently lower alcohol involvement (Colder et al., 2010). We predicted that because young adult drinking is largely a convivial behavior linked to socializing, daily positive affect would be positively associated with both the likelihood and amount of consumption at the event level. However, at the between-person level, trait positive affect was expected to be associated with lower levels of alcohol use. In contrast to the hypothesis about negative affect, associations between positive affect and dependence symptoms were predicted to be entirely indirect, via use frequency and quantity.

Affect Lability

There has been an increased call to utilize experience sampling to better understand the temporal dynamics of emotional experience (Ebner-Priemer, Eid, Kleindienst, Stabenow, & Trull, 2009; Jahng, Wood, & Trull, 2008; Trull et al., 2008) and to move beyond focusing solely on tonic level in studies of the role of emotion in the etiology of alcohol use and dependence (Jahng et al., 2011a). Study of the temporal dynamics of emotional experience can advance understanding of emotional regulation and its complex associations with alcohol use. Two closely related constructs indexing change in emotional states across time are emotional inertia (Fairbairn & Sayette, 2013) and affect lability (Jahng et al., 2008). Emotional inertia refers to consistency in emotional experience across time (Fairbairn & Sayette, 2013). Individuals high in emotional inertia experience higher levels of negative affect, and may be characterized as “dwelling” on negative emotion rather than responding to the ongoing stream of contextual influences (Fairbairn & Sayette, 2013). This quality of temporal dynamics may be assessed by serial autocorrelation of emotional states, which assesses the consistency of responses over time but not the amplitude of changes (Jahng et al., 2008). Recent research on alcohol myopia theory indicates that the effects of alcohol on mood are mediated by alcohol’s effects on decreasing emotional inertia, keeping the intoxicated person “in the moment” (Fairbairn & Sayette, 2013).

In contrast, affect lability refers to excessive variability in emotion (i.e., the frequency, speed, and range of change; Harvey, Greenberg, & Serper, 1989). Whereas emotional inertia may signify a lack of appropriate responses to contextual influences, affect lability signifies erratic, large, shifts in emotional states in response to internal or external cues. Individuals high in lability are unable to dampen emotional responses and thus lack a stable sense of emotional continuity. Affect lability is a central feature of emotional dysregulation (Jahng et al., 2011a), and this aspect of emotional dynamics is a primary focus of the current paper.

Labile affect is considered a core feature of disorders such as bipolar disorder and borderline personality, both of which confer considerable risk for substance use disorders (American Psychiatric Association, 2013; Hasin, Stinson, Ogburn, & Grant, 2007; Jahng et al., 2011b). Affect lability is associated with substance use and associated problems (Simons & Carey, 2002, 2006; Wills, Walker, Mendoza, & Ainette, 2006) and demonstrates some unique associations with alcohol dependence in clinical samples (Simons, Carey, & Wills, 2009; Simons, Oliver, Gaher, Ebel, & Brummels, 2005c). Research has indicated significant associations between affect lability and drinking among individuals with borderline personality disorder and major depression (Jahng et al., 2011a). However, among young adult samples, lability is often associated only with indicators of problematic use rather than amount of consumption (Simons & Carey, 2006; Simons et al., 2009). Importantly, research with younger samples has indicated that instability of negative affect, independent of dispositional negative affect level, predicts escalation of smoking (Weinstein, Mermelstein, Shiffman, & Flay, 2008).

Lability is strongly associated with high trait negative affect, but exhibits substantially weaker and negative associations with positive affect (Simons et al., 2005a; Weinstein et al., 2008). This may reflect shared associations between negative affect and lability with higher order personality factors (i.e., neuroticism). Alternatively, mood instability and reactivity may contribute to interpersonal or sociooccupational stress, which contribute to elevated negative affect (cf. Liu & Alloy, 2010). Thus, we hypothesize that lability will positively associated with trait negative affect. The affective processing model of negative reinforcement suggests that fluctuation in negative affect is the core mechanism driving substance dependence (Baker et al., 2004). We posit that instability of affect may foster rapid development of dependence due to pairing of frequent and rapid changes in emotion and concomitant use of alcohol.

Summary of Hypotheses and Research Methods

The present research utilized experience sampling to test a model of how affective factors are related to between- and within-person variability in alcohol use and dependence symptoms. The conceptual model is presented in Figure 1. Lability was hypothesized to predict higher trait negative affect. Associations between lability and trait positive affect, if significant, were expected to be inverse and weaker. Trait negative affect was hypothesized to be positively associated with alcohol consumption. Associations between lability and alcohol consumption, if significant, were expected to be weaker. Lability and trait negative affect were hypothesized to exhibit direct associations with dependence symptoms, above and beyond drinking level. Lability and negative affect were also expected to have indirect effects on dependence symptoms via negative affect and drinking level, respectively. Positive affect was hypothesized to be inversely associated with alcohol consumption at the between-person level and indirectly associated with dependence via this effect. However, at the within-person level, state positive and negative affect during the day were both hypothesized to be positively related to drinking and associated problems at night. Within-person, positive affect was expected to be predominantly associated with drinking level while negative affect was expected to exhibit direct associations with alcohol dependence.

With respect to assessment method, both daily (state) variables and dispositional (trait) variables were derived from the experience sampling data. Repeated *in situ* assessment of affect and the alcohol-related variables has important advantages including minimizing memory biases and establishing temporal order between the constructs (Shiffman, 2009). In the current paper, we utilize the terms daily or state to refer to time-varying variables (i.e., situational factors). In contrast, we use the terms dispositional or trait to refer to variables that are time-invariant in the study (i.e., person factors). These definitions are consistent with the goals of differentiating within- and between-person associations. We do not mean to imply that the "state" factors are momentary nor that the "trait" factors are necessarily invariant over extended periods. However, as described below, the "trait" factor does quantify the consistency of assessments over a fairly extended time (i.e., up to 49 days of ratings over 1.3 years). Although this approach toward assessing "traits" differs from retrospective personality surveys, the use of experience sampling to assess emotional traits has been advocated for some time (Diener & Emmons, 1984) and recent psychometric work supports the use of experience sampling to derive state and trait measures of affect (Merz & Roesch, 2011).

We utilized multilevel structural equation modeling (MSEM) to create latent within- and between-variables from the repeated measures data (Muthén & Muthén, 2012; Preacher et al., 2010). Figure 2 illustrates the MSEM approach with a simplified model. The between-person affect, drinking, and dependence variables (a) are unobserved latent trait factors estimated from the repeated measures data (i.e., latent estimates of the person mean across assessments). The within-person affect, drinking, and dependence measures (b) are unobserved latent state factors estimated from repeated measures data (i.e., latent person-mean centered within-person variables).

Importantly, by utilizing this approach, we are able to derive latent indicators of both state and trait components of affect from the repeated measures data. The MSEM approach also accounts for measurement error in the aggregated between-person variables that may be introduced due to the limited number of assessments (Lüdtke et al., 2008). The approach reduces biases in the estimation of the between-level effects and thus leverages the advantages of experience sampling for the testing of the between-subjects model (Lüdtke et al., 2008; Muthén & Muthén, 2012; Preacher et al., 2011; Preacher et al., 2010). In addition, the MSEM approach is ideal for integrating understanding of complex associations between individual difference factors that are stable over time (e.g., gender, genetic risk) and the study of time-varying risk factors contributing to high-risk drinking episodes. In this regard, MSEM allows for testing mediation models that incorporate different levels of measurement (i.e., within- and between- person; Preacher et al., 2010). Hence, one can test whether cluster-level variation in a Level 1 variable (i.e., the latent between-person construct) mediates the association between an observed Level 2 variable, and cluster-level variation in drinking (a latent between-person outcome). In the current study, we test what is referred to as a 2−1−1 model (Preacher et al., 2010) where the predictor (affect lability) is an observed variable on Level 2, and the mediator and outcome are measured at Level 1. Note that although the levels of measurement span levels, the resulting mediation effect refers to only one level, between-person (Preacher et al., 2010). Second, we test a 1−1−1 model (Preacher et al., 2010) where the predictor, mediator, and outcome are all measured at Level 1. Here, one is able to derive estimates of the mediated effect at both Level 1 and Level 2. However, because of the distribution of the Level 1 mediator, we focus on the between-person mediation effect. Below we present the rationale for the MSEM approach for experience sampling data, following the description of Lüdtke et al. (2008).

The standard multilevel random intercept model with group-mean centering can be expressed as follows:

$$Y_{ij}=\gamma_{00}+\gamma_{10}\left(\overline{X}_{ij}-\overline{X}_{.j}\right)+\gamma_{01}\overline{X}_{.j}+u_{0j}+r_{ij} \quad (1)$$

Y_{ij} refers to the observed score of Y on day *i* for person *j*. The predictor X_{ij} is person-centered by subtracting the individual's mean ($\bar{X}_{.j}$) from each observation. The individual's observed mean ($\bar{X}_{.j}$) is then used as a predictor at Level 2. The coefficient $\tilde{\gamma}_{10}$ is the within-person association between X and Y and the coefficient $\tilde{\gamma}_{01}$ is the between-person association between X and Y. u_{0j} and r_{ij} are residual components at Level 2 and 1, respectively. This model assumes that the person mean $\bar{X}_{.j}$ is measured without error. An alternative approach, utilized in MSEM, assumes that the person-level aggregate $\bar{X}_{.j}$ contains measurement error. That is, it is not a perfect measure of the individual's general level of X (e.g., the target trait). Experience sampling methods derive their strength, in part, by minimizing biases in retrospective recall and, hence, increasing the accuracy of the data. However, they are also necessarily relatively brief and thus estimated person-level means are based on behavior for a relatively small number of days, which can reduce their reliability. In the MSEM approach, the observed variable X_{ij} and the outcome Y_{ij} are decomposed into latent within-and between- components.

$$X_{ij}=\mu_x+U_{xj}+R_{xij} \quad (2)$$

$$Y_{ij}=\mu_y+U_{yj}+R_{yij} \quad (3)$$

X_{ij} and Y_{ij} are the observed values. μ_x and μ_y are the grand means of X and Y. U_{xj} and U_{yj} are the person-level deviation (i.e., the latent between components), and R_{xij} and R_{yij} are the daily deviations (i.e., the latent within components). In this model, U_{xj}, U_{yj}, R_{yij}, and R_{xij} are unobserved. The MSEM approach then tests associations between these latent variables

$$R_{yij}=\beta_{\text{within}}R_{xij}+\varepsilon_{ij} \quad (4)$$

$$U_{yi}=\beta_{\text{between}}U_{xj}+\delta_{j} \quad (5)$$

Hence, equation 1 can be rewritten:

$$Y_{ij} = \mu_y + \beta_{\text{within}} R_{xij} + \beta_{\text{between}} U_{xj} + \delta_j + \varepsilon_{ij} \quad (6)$$

The above substitutes the latent within variable R_{xij} for $(X_{ij} - \bar{X}_{.j})$ and substitutes the latent between variable U_{xj} for $\bar{X}_{.j}$ in equation 1.

Also, as depicted in Panel C, we utilize the experience sampling data to estimate affective instability (i.e., lability) across successive assessments (Ebner-Priemer et al., 2009; Jahng et al., 2008). Hence, we derive three properties from the time-series emotion data (i.e., state affect, trait affect, and trait lability).

Method

Participants

Participants were 274 undergraduate college students at two Midwest universities. The sample ranged from 18 to 27 years of age (M = 19.88, SD = 1.37). The sample was 56% female and was 93% White, 1% African American, 1% Asian, 1% Native American, 1% Native Hawaiian/Pacific Islander, and 3% other race or did not respond; 3% of the sample were Hispanic. The sample demographic characteristics are comparable with the university populations, which have approximately 60% women and 6–14% ethnic minorities. Recruitment was conducted through e-mail notices and advertisements in local media.

Procedure

Undergraduates between ages 18 and 25 years who drank at least moderately (i.e., ≥12 drinks/week for women and ≥16 drinks/week for men; Sanchez-Craig, Wilkinson, & Davila, 1995) were invited to participate in the experience sampling (ESM) study. Invited participants provided informed consent for the study, completed a set of baseline questionnaires, and were then trained in the use of the PDA. Palm handhelds were programmed with PMAT software (Weiss, Beal, Lucy, & MacDermid, 2004), modified by Joel Swendsen and CNRS, France. The program was configured to prompt participants to complete brief ~2-minute assessments at random times within 2-hr blocks between 10:00 a.m. and 12:00 midnight. The ESM questionnaire included affect, alcohol consumption, and dependence symptoms assessments. For the random assessments, questionnaire items inquired about the participant's behavior for the past 30 minutes. Participants were asked to answer questionnaires during waking hours and could turn the machine off when they would be sleeping or otherwise would be disturbed by it (e.g., taking an exam). In addition, participants completed an initial morning assessment shortly after waking each day. The morning assessment contained additional questions regarding alcohol use problems the previous evening to assess behaviors that were unlikely to be reported at a random prompt (e.g., passing out). To establish a clear temporal order between affect and the drinking related outcomes, the data are structured such that the daytime affect assessment interval precedes the subsequent nighttime drinking related assessment interval. The drinking and dependence symptom measures are contemporaneous within each assessment night. The validity of the proposed sampling design is supported by previous research (Armeli et al., 2003; Simons et al., 2010; Simons et al., 2005b; Swendsen et al., 2000). Research with undergraduates has not indicated significant reactivity to in vivo sampling in respect to drinking behavior (Hufford, Shields, Shiffman, Paty, & Balabanis, 2002), and the observed relationships between alcohol intoxication and various behavioral risks do not appear to be subject to reactivity bias (Neal & Fromme, 2007).

To increase the coverage of the experience sampling data, participants carried the PDA for 1 to 2 weeks during two periods in the fall and spring semesters (3 semesters total), resulting in 6 measurement bursts totaling 49 days of data. A measurement burst design utilizes repeated sequences of short periods (e.g., weeks) of intensive (e.g., hourly) assessments (Sliwinski, 2008). This approach allows for detailed momentary assessments during each measurement “burst” (e.g., a week of experience sampling) yet by spacing the bursts allows for assessment of behavior over a longer period of time without fatiguing participants. The study employed a rolling enrollment process and thus the timing of the bursts varied. However, within semester the first burst was toward the beginning and the second toward the end of the semester, avoiding the first couple of weeks of the semester and final exams. Participants received payment for their participation. Individuals received $20 for the baseline assessment and then received payments contingent on response rates during each burst (up to $25/week). Participants completing all 6 bursts received a $50 bonus. All procedures were approved by the IRBs at the two universities.

Measures

Baseline questionnaire

Alcohol consumption: Drinking was assessed by the Modified Daily Drinking Questionnaire (Dimeff, Baer, Kivlahan, & Marlatt, 1999), which consisted of a grid representing the seven days of the week. The grid assessed participants’ typical daily alcohol consumption and number of hours spent drinking for a typical week during the last six months. This measure was used only for screening purposes, to select participants for the study who had a certain level of drinking.

Alcohol dependence: A *Diagnostic and Statistical Manual of Mental Disorders*, fourth edition (*DSM–IV*) alcohol dependence symptom checklist (Knight et al., 2002) was included to examine criterion validity of the *in situ* assessments of dependence symptoms. This 7-item checklist has been used in previous studies of college students and has expected relations with drinking-related variables.

Experience sampling measures

Affect: Positive and negative affect in the previous 30 minutes were assessed by items from subscales of the PANAS-X (Watson & Clark, 1994) and Larsen and Diener’s affect circumplex model (Larsen & Diener, 1992). Cronbach’s alphas were calculated for one signal per person on one day in each burst. We report the mean of the six estimates. Positive affect was assessed by 5 items from the joviality subscale: happy, joyful, excited, energetic, and enthusiastic ($\alpha = .91$). Negative affect was assessed by 9 items reflecting sadness, anxiety, and anger: sad, blue, downhearted, nervous, jittery, anxious, angry, hostile, irritable ($\alpha = .80$). Items were rated on 7-point scales ranging from 1 = *not at all* to 7 = *extremely*. Previous research supports the internal consistency and criterion validity of these and comparable affect scales assessed by experience sampling (Armeli et al., 2003; Csikszentmihalyi & Larson, 1987; Simons et al., 2010; Simons et al., 2005b). Daytime affect was defined as the person's mean across signals between 10 a.m. and 5 p.m. The MSEM approach creates latent within- (i.e., daily or state) and between- (i.e., dispositional or trait) person factors from the experience sampling data.

Lability: Affect lability was assessed by mean squared successive difference (MSSD) analysis of the *in situ* positive and negative affect ratings during the daytime (Ebner-Priemer et al., 2009; Jahng et al., 2008). This approach takes into account the temporal associations (i.e., time between emotion assessments [speed of change]), amplitude (i.e., range of change), and frequency of shifts in affect. We utilized the MSSD "city" approach (Ebner-Priemer et al., 2009), which extends the MSSD approach to a two dimensional space (positive and negative affect in this case) by calculating rectangular distances between successive assessments of positive and negative affect.

$\text{MSSD}=\frac{\sum_{i=2}^{n}(|x_i-x_{i-1}|+|y_i-y_{i-1}|)^2}{n-1}$. This approach has demonstrated good differentiation of simulated stable and unstable temporal patterns (Ebner-Priemer et al., 2009). There are many alternative approaches to assessing lability, including surveys (Oliver & Simons, 2004), the within-person standard deviation (Jahng et al., 2008; Larson, Csikszentmihalyi, & Graef, 1980), and autocorrelation (Fairbairn & Sayette, 2013; Jahng et al., 2008). Surveys benefit from ease of use and the ability to assess behavior over extended periods, yet rely on individual self-evaluation. The within-person standard deviation of the measurements provides an estimate of the variability of emotional experience but does not account for the sequencing and temporal shifts (Jahng et al., 2008). The autocorrelation assesses persistency of emotion, but does not capture the magnitude of shifts in emotion (Jahng et al., 2008). For these reasons, the MSSD is a preferred measure (Ebner-Priemer et al., 2009; Jahng et al., 2008). The MSSD can be extended to account for variability in assessment intervals (Jahng et al., 2008). In the present study we are assessing lability during the daytime hours, so not to confound the effects of potential drinking episodes in the night. Hence, all successive assessments are spaced approximately 2 hours apart (i.e., successive differences do not span across missing data points, across days, nor across measurement bursts). This assessment of lability reflects mean changes in affect between successive time points over the course of the study. Whereas any one large change may reflect a potent contextual influence (e.g., an argument with romantic partner), high scores on the lability measure reflect consistently large changes between successive assessments over the entire study period.

Alcohol consumption: Alcohol consumption was assessed by *in situ* assessments of drinks. Participants reported the number of drinks they consumed over the past 30 minutes on an 8-point scale (0 – 7 or more drinks). Definitions of standard drinks were provided during the palmtop training. Validity of the alcohol assessments is supported by significant associations with transdermal alcohol monitoring on a random subset of participants for 2 assessment bursts (Wray, Reed, Hunsaker, Finn, & Simons, 2012). Transdermal assessment correctly classified 86% of the drinking days. Discrepancies between transdermal assessment and self-report were predominantly the transdermal assessment not identifying light drinking days (i.e., there was not evidence of participants denying drinking). In addition, there was good correspondence between peak transdermal readings and self-reported number of drinks from the daily assessments. Though the transdermal data cannot determine the number of drinks, the associations between the self-report and biochemical data provide support for the validity of the data. The assessment indicates behavior occurring after 5 p.m. each day. The L1 (within-person) and L2 (between-person) drinking variables are created within the MSEM modeling framework from the repeated measures data.

Dependence symptoms: Symptoms of alcohol dependence and high risk drinking were assessed following procedures of Simons et al. (2010). Validity of the approach is supported by expected within-person associations and moderate associations with proxy alcohol dependence diagnoses (Simons et al., 2010). Alcohol dependence is generally considered an individual difference characteristic that reflects a cumulative pattern of behavior over time. Thus, such symptoms are not usually assessed via *in situ* or daily assessment methods. However, as indicated in Figure 1, person-level traits may be considered latent constructs that manifest in observed behaviors that vary within the individual. In this regard, the repeated assessment of drinking related behaviors characteristic of alcohol dependence can be utilized to assess symptoms of alcohol dependence both as a person-level characteristic and a time-varying expression of symptoms. Random *in situ* assessments included a 7-item checklist with the following choices: (a) felt sick or vomited; (b) drank when you promised yourself not to; (c) had withdrawal symptoms; (d) tried unsuccessfully to limit your drinking, cut back, or stop; (e) drank more or for a longer time than you intended; (f) drank more than usual to get drunk; and (g) felt alcohol effects less than usual for amount used. The morning assessment assessed whether the participant (a) passed out, (b) blacked out, (c) vomited, (d) needed to drink more than usual to get the desired effect, (e) felt less effects than usual for the amount drank the previous night, (f) a.m. withdrawal symptoms, and (g) hangover. Definitions of blackouts, withdrawal symptoms, and hangovers were provided during the palmtop training. The morning assessment was designed, in part, to pick up symptoms that might be missed in the random sampling. Items in the morning assessment that corresponded to items in the random assessments (e.g., felt effects less for amount used) were recoded to zero if the item had been endorsed in the evening. This eliminates inadvertently counting an event twice. After recoding, the sum total of items endorsed for the repeated nighttime assessments and the morning assessments was the measure of acute dependence symptoms. This is an assessment of acute dependence symptoms experienced after 5 p.m. The L1 (within-person) and L2 (between-person) dependence variable is created within the MSEM modeling framework from the repeated measures data.

Analysis Plan

We analyzed a multilevel structural model in Mplus 7.1 (Muthén & Muthén, 2012) with days nested within person. The model contained 4 event-level (i.e., time varying within-person) constructs with random intercepts: Daytime positive and negative affect, nighttime number of drinks, and nighttime dependence symptoms. Daytime affect scores were continuous variables. Dependence symptoms were specified as a count with a negative binomial distribution. Nighttime drinking was specified as a zero-inflated negative binomial distribution (Lambert, 1992; Simons, Neal, & Gaher, 2006). Inspection of the AIC and BIC for the zero-inflated versus negative binomial model favored the zero-inflated model (Zero-inflation: BIC = 78246.72, AIC = 77644.81 vs. Negative Binomial: BIC = 80241.32, AIC = 79768.39). This thus allows us to model number of drinks on potential drinking nights (the count portion) as well as the likelihood of abstaining (the likelihood of "always" zero; i.e., 0s in excess of that expected by the negative binomial distribution).[1] The equations for the count outcomes included an exposure variable equal to the number of random assessments completed for the night, in order to control for differences in response rates. At both the within-person (i.e., Level 1, L1) and the between-person (i.e., Level 2, L2) level, acute dependence symptoms were regressed on alcohol consumption and alcohol consumption was regressed on positive and negative affect. Rather than utilizing the observed means at L2, the affect and drinking covariates were decomposed into two latent variable parts reflecting the within- and between-sources of variability. This approach reduces bias in estimates of between-person effects and separates the within- and between- person effects (Lüdtke et al., 2008; Muthén & Muthén, 2012; Preacher et al., 2010). The model thus provides a particularly rigorous test of the hypothesized associations. We sequentially tested for random variance in the slopes. None of the slopes had substantial random variance components and thus all slopes were estimated as fixed effects to simplify model estimation.

At L1, six orthogonal day of the week indicator predictors were included to address daily variation in mood and drinking as well as the potential serial auto-correlation across days (cf. Mohr et al., 2001). In addition, an indicator for semester was included to control for variation in the outcomes by semester. Finally, an elapsed-days variable was included representing the number of days since initiating the study. This controls for change over time as a function of either development or reactivity to the assessment protocol. At L2, age, gender (dichotomous), university (dichotomous), and number of days in the study were exogenous variables predicting the L2 outcomes. The positive and negative affect residuals were allowed to covary at both levels. Exogenous L1 variables were centered at the person-mean and lability, and the time and demographic covariates at L2 were centered at the grand-mean. We utilized a model building approach (i.e., increasing model complexity in steps) to sequentially examine the hypotheses and create a parsimonious model (see results). Estimated equations are presented in the Appendix.

We utilized multiple imputation to replace missing variables in the analyzed data matrix. This imputes data into the incomplete person-days (i.e., data is imputed for days an individual carried the PDA). The imputation does not replace data that are completely missing (i.e., attrition), as the missing days do not exist. The proportion of missing data ranged from 3.5% (night drinks) to 7.9% (daytime negative affect). Twenty datasets were imputed using Bayesian estimation of an unrestricted variance-covariance model in Mplus 7 (Asparouhov & Muthen, 2010; Muthén & Muthén, 2012) that included all variables in the hypothesized model (Enders, 2010). These datasets were then analyzed using the maximum likelihood robust estimator (MLR) and parameter estimates and standard errors calculated using the Rubin formula (Muthén & Muthén, 2012). MLR and multiple imputation are

[1]The zero-inflation model predicts zero scores in excess of what is expected by the count distribution. However, for clarity, we refer to this in respect to abstaining or inversely drinking likelihood. This reflects days when the individual is "never" expected to drink, true zero scores.

appropriate when data are missing completely at random (MCAR; missingness is unrelated to any variable) or missing at random (MAR; missingness related to one or more observed variables but not with the dependent variable after partialing out other variables; Enders, 2010). There is no direct test of whether data are missing not at random (MNAR; missingness related to one or more unobserved variables, Allison, 2003). However, MLR estimation and multiple imputation can perform well even when data are MNAR (Enders, 2010). We followed an "inclusive" analysis strategy (Enders, 2010) and incorporated variables into the imputation model that may account for missingness (e.g., day of the week, age, number of days in the study). This approach increases the likelihood of meeting the MAR assumption (Enders, 2010). Full-information maximum likelihood estimation (FIML) also provides unbiased parameter estimates under MAR assumptions (Enders, 2010) and is equivalent to analysis of imputed data (Asparouhov & Muthen, 2010). However, in models that require numerical integration (such as ours), missing data in mediators require the use of Monte Carlo integration. Hence, multiple imputation is an optimal strategy for estimating this MSEM.

Results

Attrition and Response Analysis

Of 274 participants initially enrolled, 11 were dropped because of poor compliance with the protocol, resulting in an analytic sample of 263. The participants in the analysis sample completed 79% of the random prompts (25th percentile – Median – 75th percentile: 71% – 83% – 89%) and 96% of the morning assessments, which compares favorably with data from other experience sampling studies (cf. Piasecki et al., 2011; Shiffman, 2009; Stone & Shiffman, 2002). Shiffman (2009) reviews use of EMA methods in substance use research and notes a range of response rates from 50% to 90%, with the majority of studies falling in the range of 75% to 80%.

An average of 268.98 (*SD* = 162.26; Median = 376, range 7 – 562) days elapsed between participants' first and last assessments. On average, the 263 participants provided daily data on 74% of the targeted 49 assessment days. The mean number of assessment days per participant was 36.36 (*SD* = 13.91; 25th percentile – median – 75th percentile: 21 days – 42 days – 49 days). Number of assessment days was not correlated with baseline drinking or gender (*r*s < .05), or with measures of dependence symptoms, positive affect, or negative affect during the study (*r*s < .06). The number of assessment days was inversely associated with reported drinking during the experience sampling study ($r = -.19$, $p = .01$). Participants at the PI's university completed more assessment days ($r = .23$, $p = .0002$).

Descriptive Statistics

Participants reported drinking on 27% of the study days and reported drinking an average of 4.73 (*SD* = 3.95) drinks per drinking day. Participants reported at least 1 symptom of dependence or high-risk drinking on 21% of drinking days and a mean of 1.44 (*SD* = 2.12) dependence-related symptoms per drinking day. Table 1 contains descriptive statistics. Zero-order correlations between the L2 variables are in Table 2. The *DSM–IV* alcohol dependence checklist indicated 27.97% of the sample met criteria for current alcohol dependence. As expected given the selection criteria, this is substantially higher than estimates of alcohol dependence among college student past-year drinkers in the NESARC sample (14.5%; Dawson, Grant, Stinson, & Chou, 2004). Thus the sampling strategy was successful in recruiting high-risk drinkers. Dependence symptoms assessed via experience sampling (subject means across the study) were strongly associated with meeting alcohol dependence criteria at baseline, $t(105.58) = -4.55$, $p < .0001$, Cohen's $d = 0.71$. The association between baseline assessment of alcohol dependence and the experience sampling of dependence symptoms supports the criterion validity of the *in situ* assessments.

MSEM Analysis

The intraclass correlation was .41 for negative affect and .47 for positive affect, indicating 41% to 47% of the variance in mood was at the between-person level and 53% to 59% within-person. Intraclass correlations are not available for the count outcomes. Because of the complexity of the analysis, we used a model-building strategy so as to minimize the probability of Type I error and to develop a parsimonious model. At each step, joint tests of conceptually related effects (i.e., a multivariate test of all effects being zero) were conducted and information criteria (i.e., AIC, BIC) were examined to determine whether to add the hypothesized effects. Table 3 reports the result of the model building steps, linking each step to the study hypotheses. The parameter estimates for the final model are depicted in Tables 4 and 5. Table 6 provides a summary of the main hypotheses and findings. The final model is depicted in Figure 3. In the presentation that follows, associations between variables have positive sign unless otherwise noted.

Model building summary—The baseline model included positive and negative affect (at L1 [i.e., within-person] and L2 [i.e., between-person]), L1 time covariates, and L2 lability, age, gender, site, and time in study as predictors (Step 1). Paths for the L2 covariates of age, site, and length of time enrolled were limited to the significant bivariate effects. The effects of lability and positive and negative affect were indirect via alcohol use. Step 2 tested the within- and between-person direct effects of negative affect on dependence symptoms. Step 3 tested the hypothesized direct effect of lability on dependence symptoms. These models are summarized in Table 3.

Results presented in Table 5 indicate that, as expected, there was a significant within-person effect of drinking on dependence symptoms: Acute dependence symptoms were greatest on heavier drinking days. At the between-person level, proportion of abstinent days was inversely associated with dependence symptoms. However, mean number of drinks per drinking day exhibited a weaker, marginally significant, association with dependence symptoms. This suggests, that among relatively heavy drinking young adults, the proportion of drinking versus abstinent days may be a better indicator of developing problems than the level of consumption on drinking days.

Negative affect: Within- and between-person associations—Consistent with hypothesis there was a significant within-person association between state negative affect and greater alcohol consumption when drinking. However, state negative affect was not associated with an increased likelihood of drinking at the daily level. At the between-person level, the opposite pattern was found. Trait negative affect was inversely associated with the proportion of abstinent days, but not associated with the mean amount of drinks on drinking nights. Step 2 supported the hypothesized direct effects of daytime negative affect on dependence symptoms, over and above the effect of consumption. These effects were significant at both the within- and between-person level. However, once the affect lability path was added in Step 3, only the within-person direct effect was significant. There was a significant indirect association between trait negative affect and dependence symptoms via proportion of abstinent days ($ab = 0.12$, $p = .049$). However, the total effect was not significant ($b = 0.23$, $p = .099$).

Positive affect: Within- and between-person associations—State positive affect was associated with an increased likelihood of drinking the subsequent night and greater alcohol consumption when drinking. As hypothesized, individuals characterized by higher trait positive affect abstained from drinking a greater proportion of days and consumed marginally less alcohol on drinking days over the course of the study. This pattern is consistent with hypothesized discordance in associations between positive affect and drinking at the within- and between-person level. Also, consistent with hypothesis, associations between positive affect and dependence symptoms were indirect via alcohol use. At the between-person level, trait positive affect had a significant indirect effect via the proportion of drinking days ($ab = -0.08$, $p = .029$) and was significantly inversely associated with dependence (total effect = −0.11, $p = .008$).

Lability—As indicated in Table 4, the analysis supported the hypothesized effect of lability on trait negative affect. Step 3 supported the hypothesized direct effect of lability on dependence symptoms. Once controlling for lability, the between-person direct effect of trait negative affect on dependence symptoms was not significant. Hence, the model indicates that instability of affect rather than dispositional negative affect is associated with between-person differences in dependence symptoms (see Table 5). Affective lability had a significant total effect on alcohol dependence symptoms (total effect = 0.12, $p < .001$). This was largely a function of the substantial direct effect and marginal indirect effect via trait negative affect and proportion of abstinent days ($ab = 0.02$, $p = .060$). Indirect effects via trait positive affect and alcohol use were not significant.

Discussion

This longitudinal study utilized multilevel structural equation modeling to test hypotheses about the contributions of within- and between-person affective constructs to alcohol use and to symptoms of dependence and high-risk drinking. The analytic model distinguished between variables that predicted the likelihood of drinking versus not drinking and variables that predicted the amount of alcohol consumed at times when a person did drink. The research design and data analytic approach provide a robust evaluation of factors contributing to alcohol use and dependence symptoms among a sample of moderate- to heavy-drinking young adults. In the following sections, we discuss the findings with respect to the theoretical rationale that formed the basis for the research design.

Positive and Negative Affect: Within- and Between-Person Associations

At the within-person (i.e., state) level, positive and negative affect during the day were related to heavier consumption when drinking that night, and positive affect also predicted an increased likelihood of drinking. However, at the between-persons (i.e., trait) level, dispositional positive affect was related to a lower proportion of drinking days and fewer dependence symptoms, whereas negative affect was related to a greater proportion of drinking days. Thus, the current study provides empirical support for suggestions derived from review of literature indicating that associations between affect and drinking may differ within- and between-person (Colder et al., 2010).

Traits and behavioral characteristics can be measured by aggregating behavior across time points. Individuals who are "happy" should exhibit more positive affect across successive time points. That is, given an adequate sampling of time, there should be correspondence between traits and aggregated state measures. This basic observation has led to the assumption that associations between constructs at the state and trait level should also correspond. Indeed, although many psychological theories are inherently about within-person processes, research frequently focuses on between-person data (Curran & Bauer, 2011). This is attributable, in part, to an underlying assumption that between-person associations will correspond to the hypothesized within-person processes (and vice versa). Our data indicates that this is not a valid assumption, and that explicating associations between alcohol use and positive affect at the within- and between-person level require distinct theoretical propositions.

We posit that a trait such as positive affectivity has a broad range of influences on individuals' psychosocial context. Indeed, the "broaden-and-build" theory of positive affect argues that positive affect serves to promote enduring changes in psychosocial resources (Fredrickson, 2001). Trait differences in positive affectivity contribute to engagement in recreational activities, academic and occupational pursuits, health behaviors such as exercise, quality of social relationships, and engagement in prosocial community and religious activities (Lyubomirsky, King, & Diener, 2005). These contexts and competing sources of reinforcement influence habitual drinking patterns in a manner distinct from acute changes in affect, resulting in healthier behavior patterns observed among "happy" people (Lyubomirsky et al., 2005). These indirect effects of trait positive affectivity contribute to the individual's characteristic drinking profile (e.g., the mean and range). However, within this contextually prescribed range, daily variation in positive affect promotes deviations from the person-mean that are incongruent with the trait effect. Acute changes in positive affect can promote appetitive behavior (Chiu, Cools, & Aron, 2014; Rothbart & Sheese, 2007) and alcohol is used to celebrate positive events (Neighbors et al., 2011). In addition, the within-person effects of positive affect may, in part, reflect anticipation. That is, anticipating a night of heavy drinking may contribute to increases in positive affect during the day. In the current study, the effects of state positive affect were significant when controlling for day of the week, which is likely associated with social events among college students. However, ultimately, daytime positive affect and subsequent nighttime drinking behavior among young adults may have a reciprocal relationship via expectations.

The results indicate that whereas drinking occasions are predominantly associated with positive affect, negative affect serves to contribute to more maladaptive drinking patterns and associated problems. At the state level, this is consistent with experimental findings on the role of negative affect in promoting impulsive behavior. Individuals prioritize mood repair over achieving more long-term adaptive goals (cf. Tice, Bratslavsky, & Baumeister, 2001). Furthermore, high arousal may compromise effective self-control (Lieberman, 2007). Though negative affect may not predict likelihood of drinking on a given day, when individuals in a negative mood do drink, their behavior is poorly controlled and excessive. These processes may not be entirely conscious but individuals with high negative affect may be implicitly biased toward drinking cues, have impaired executive control, and hence are more likely to drink to excess and experience associated problems (Baker et al., 2004; Wiers et al., 2007; Wills, Pokhrel, Morehouse, & Fenster, 2011).

In summary, the pattern of results is consistent with theoretical models that emphasize positive reinforcement mechanisms for drinking among young adults (Wardell, Read, Colder, & Merrill, 2012), negative reinforcement processes of substance dependence (Baker et al., 2004), and trait positive affect as a protective factor (Lyubomirsky et al., 2005; Wills & Ainette, 2010). Each theoretical mechanism appears accurate for explaining a portion of a complex phenomenon that includes the likelihood of drinking, the amount consumed on drinking days, and the tendency to experience dependence symptoms.

Affect Lability

The results add to literature indicating the significant role of affective instability in the development of substance dependence (Simons et al., 2009; Simons et al., 2005c; Weinstein et al., 2008). As hypothesized, lability was positively associated with negative affect at the between-person level. However, consistent with previous research, lability exhibited associations with substance use outcomes independent of dispositional affect level (Simons et al., 2005a; Weinstein et al., 2008) and a direct association with dependence symptoms over and above the effects of drinking frequency and quantity (Simons et al., 2005c). Although the pattern of results is complex and varies across timeframe and diagnostic group, research in clinical samples has highlighted the role of affect lability in drinking behavior among individuals with borderline personality and depressive disorders (Jahng et al., 2011a). Given the pivotal role of negative affect and substance use cyclical pairings in negative reinforcement models (Baker et al., 2004), these findings suggest that lability may be an important risk factor for the development of substance dependence and contribute to the maintenance of substance use over time. Specifically, we suggest that the frequency and intensity of shifts in affect facilitate and strengthen conditioned associations between emotional arousal and drinking. In addition, acute spikes in affective arousal can impair deliberative control mechanisms and increase reflexive, automatic processes (Baker et al., 2004; Lieberman, 2007). Furthermore, this decrease in deliberative control processes is thought to increase the effects of implicit associations on behavior (Hofmann & Friese, 2008; Hofmann, Friese, & Strack, 2009). Hence, labile affect sets the stage for drinking that is compulsive and poorly controlled, symptoms characteristic of alcohol dependence.

Previous studies have shown emotional dysregulation is related to substance use independent of poor behavioral regulation (Wills et al., 2013; Wills et al., 2011). The current study showed affect lability was associated with significantly higher dependence symptoms, independent of trait affect, proportion of drinking days, or level of consumption on drinking days. In fact, consistent with previous research on young adults, lability was associated with dependence symptoms but not characteristic drinking level (Simons & Carey, 2006; Simons et al., 2009). We posit that poor regulation of emotion contributing to a pattern of pronounced temporal instability in emotion fosters dysregulation of drinking behavior characteristic of alcohol dependence.

Limitations

Some possible limitations of the present study should be considered for interpretation of the results. First, as mentioned previously, attrition was modestly associated with drinking level. However, in the analysis we included drinking level and several individual difference covariates that we expect make the missing at random assumptions tenable and hence the results not adversely affected by bias. Second, though this is a complex model it is limited in that it does not include additional important familial and environmental factors that are relevant for understanding young adult drinking (cf. Simons et al., 2009). Third, previous research indicates that specific emotions (e.g., anxiety, anger, sadness) may exhibit unique associations with alcohol behavior and associations between affect and drinking could exhibit time lags of several days (Armeli et al., 2008; Hussong, 2007; Hussong & Chassin, 1994; Simons et al., 2010). In addition, our assessment of lability is an index of emotional instability across both positive and negative emotions. Hence, it does not differentiate instability in positive versus negative emotions. Because of the complexity of our model, we were unable to examine these issues. Nonetheless, the patterns of emotional functioning exhibit expected associations with the alcohol outcomes. Finally, as with all observational studies it is possible that observed between-person associations between lability or trait negative affect and the alcohol outcomes could be the result of unobserved third variables (e.g., shared genetic risk) or alternatively reflect the effects of heavy alcohol use on emotional functioning rather than vice versa. Linkages between emotional functioning and drinking likely reflect complex reciprocal associations as well as shared vulnerability factors.

Clinical Implications

The pattern of results indicates that specific deficits in emotional regulation are a core issue underlying alcohol use patterns and dependence symptoms. Interventions that promote affect regulation skills may reduce risk of alcohol dependence. Maladaptive behavior is most likely when individuals are affectively aroused and have difficulty modulating behavioral responses. High and rapidly changing emotional arousal may contribute to response biases promoting maladaptive alcohol consumption patterns and the development of dependence (Baker et al., 2004; Wiers et al., 2007). Interventions that serve to reduce emotional lability may be important adjuncts to approaches that emphasize more deliberative mechanisms (e.g., decisional-balance exercises). Similarly, directly targeting implicit associations linking changes in emotional arousal and drug use may be important to maximize treatment effectiveness (Wiers, Gladwin, Hofmann, Salemink, & Ridderinkhof, 2013; Wills, Simons,

& Gibbons, in press). Moreover, the findings on the protective role of positive affect suggest the importance of building alternative reinforcers so as to reduce the risk-promoting influence of negative affect (Carroll, 1996; Carroll, Bickel, & Higgins, 2001; Murphy, Correia, & Barnett, 2007; Wills et al., 1999).

Summary

The results indicate affect lability contributes to observed differences in alcohol dependence symptoms. Although daily increases in positive arousal were associated with increased drinking, trait positive affect was associated with a lower proportion of drinking days and fewer dependence symptoms over the course of the study. Similarly, the effects of negative affect on drinking differed across the within- and between- person levels. These patterns of results exemplify how trait affect, because of its pervasive effects on psychosocial functioning, can exhibit associations with behavior that are discordant with effects of emotion at the within-person level. Acute effects of emotion on drinking behavior may be conditional upon contextual factors. Trait affect is one of a broad range of influences on the development of social contexts and drinking patterns. The effect of trait affect on contextual factors contributing to drinking behavior need not be the same as the effect of emotion on behavior within a given context. The within-person effects of negative affect and between-person effects of affect lability on dependence symptoms over and above drinking frequency and quantity, suggest that the intraindividual context in which drinking occurs affects risk for dependence. Instability of emotion may contribute to a shift in young adults from time-limited celebratory drinking toward a more persistent and dyscontrolled style of drinking tied to negative affect.

Acknowledgments

This research was supported in part by National Institute on Alcohol Abuse and Alcoholism Grant R01AA017433 (Jeffrey S. Simons) and by National Institute on Drug Abuse Grant R01 DA021856 and National Cancer Institute Grant P30 CA071789 (Thomas A. Wills).

References

Allison JD. Missing data techniques for structural equation modeling. Journal of Abnormal Psychology. 2003; 112:545–557. [PubMed: 14674868]

American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders. 5th. Washington, DC: American Psychiatric Association; 2013.

Armeli S, Tennen H, Todd M, Carney MA, Mohr C, Affleck G, Hromi A. A daily process examination of the stress-response dampening effects of alcohol consumption. Psychology of Addictive Behaviors. 2003; 17:266–276. [PubMed: 14640822]

Armeli S, Todd M, Conner TS, Tennen H. Drinking to cope with negative moods and the immediacy of drinking within the weekly cycle among college students. Journal of Studies on Alcohol and Drugs. 2008; 69:313–322. [PubMed: 18299774]

Asparouhov T, Muthen BO. Multiple Imputation with Mplus. 2010 Retrieved from http://statmodel2.com/download/Imputations7.pdf.

Baker TB, Piper ME, McCarthy DE, Majeskie MR, Fiore MC. Addiction motivation reformulated: An affective processing model of negative reinforcement. Psychological Review. 2004; 111:33–51. [PubMed: 14756584]

Bowirrat A, Oscar-Berman M. Relationship between dopaminergic neurotransmission, alcoholism, and reward deficiency syndrome. American Journal of Medical Genetics. Part B, Neuropsychiatric Genetics. 2005; 132B:29–37.

Carroll, ME. Reducing drug abuse by enriching the environment with alternative nondrug reinforcers. In: Green, L.; Kagel, JH., editors. Advances in behavioral economics, Vol. 3: Substance use and abuse. Westport, CT: Ablex Publishing; 1996. p. 37-68.

Carroll, ME.; Bickel, WK.; Higgins, ST. Nondrug incentives to treat drug abuse: Laboratory and clinical developments. In: Carroll, ME.; Overmier, JB., editors. Animal research and human health: Advancing human welfare through behavioral science. Washington, DC: American Psychological Association; 2001. p. 139-154.

Chiu YC, Cools R, Aron AR. Opposing effects of appetitive and aversive cues on go/no-go behavior and motor excitability. Journal of Cognitive Neuroscience. 2014

Colder CR, Chassin L. Affectivity and impulsivity: Temperament risk for adolescent alcohol involvement. Psychology of Addictive Behaviors. 1997; 11:83–97.

Colder, CR.; Chassin, L.; Lee, MR.; Villalta, IK. Developmental perspectives: Affect and adolescent substance use. In: Kassel, JD., editor. Substance abuse and emotion. Washington, DC: American Psychological Association; 2010. p. 109-135.

Cooper ML. Motivations for alcohol use among adolescents: Development and validation of a four factor model. Psychological Assessment. 1994; 6:117–128.

Cox WM, Klinger E. A motivational model of alcohol use. Journal of Abnormal Psychology. 1988; 97:168–180. [PubMed: 3290306]

Csikszentmihalyi M, Larson R. Validity and reliability of the experience-sampling method. Journal of Nervous and Mental Disease. 1987; 175:526–536. [PubMed: 3655778]

Curran PJ, Bauer DJ. The disaggregation of within-person and between-person effects in longitudinal models of change. Annual Review of Psychology. 2011; 62:583–619.

Dawson DA, Grant BF, Stinson FS, Chou PS. Another look at heavy episodic drinking and alcohol use disorders among college and noncollege youth. Journal of Studies on Alcohol. 2004; 65:477–488. [PubMed: 15378804]

Diener E, Emmons RA. The independence of positive and negative affect. Journal of Personality and Social Psychology. 1984; 47:1105–1117. [PubMed: 6520704]

Dimeff, LA.; Baer, JS.; Kivlahan, DR.; Marlatt, GA. Brief alcohol screening and intervention for college students (BASICS): A harm reduction approach. New York, NY: Guilford Press; 1999.

Ebner-Priemer UW, Eid M, Kleindienst N, Stabenow S, Trull TJ. Analytic strategies for understanding affective (in)stability and other dynamic processes in psychopathology. Journal of Abnormal Psychology. 2009; 118:195–202. [PubMed: 19222325]

Enders, CK. Applied missing data analysis. New York, NY: Guilford Press; 2010.

Fairbairn CE, Sayette MA. The effect of alcohol on emotional inertia: A test of alcohol myopia. Journal of Abnormal Psychology. 2013; 122:770–781. [PubMed: 24016015]

Fredrickson BL. The role of positive emotions in positive psychology. The broaden-and-build theory of positive emotions. American Psychologist. 2001; 56:218–226. [PubMed: 11315248]

Glantz, MD.; Weinberg, NZ.; Miner, LL.; Colliver, JD. The etiology of drug abuse: Mapping the paths. In: Glantz, MD.; Hartel, CR., editors. Drug abuse: Origins & interventions. Washington, DC: American Psychological Association; 1999. p. 3-45.

Harvey PD, Greenberg BR, Serper MR. The affective lability scales: Development, reliability, and validity. Journal of Clinical Psychology. 1989; 45:786–793. doi: 10.1002/1097-4679(198909)45:5<786:: AID-JCLP2270450515>3.0.CO;2-P. [PubMed: 2808736]

Hasin DS, Stinson FS, Ogburn E, Grant BF. Prevalence, correlates, disability, and comorbidity of *DSM–IV* alcohol abuse and dependence in the United States: Results from the National Epidemiologic Survey on Alcohol and Related Conditions. Archives of General Psychiatry. 2007; 64:830–842. [PubMed: 17606817]

Hofmann W, Friese M. Impulses got the better of me: Alcohol moderates the influence of implicit attitudes toward food cues on eating behavior. Journal of Abnormal Psychology. 2008; 117:420–427. [PubMed: 18489218]

Hofmann W, Friese M, Strack F. Impulse and self-control from a dual-systems perspective. Perspectives on Psychological Science. 2009; 4:162–176. [PubMed: 26158943]

Hufford MR, Shields AL, Shiffman S, Paty J, Balabanis M. Reactivity to ecological momentary assessment: An example using undergraduate problem drinkers. Psychology of Addictive Behaviors. 2002; 16:205–211. [PubMed: 12236455]

Hussong AM. Predictors of drinking immediacy following daily sadness: An application of survival analysis to experience sampling data. Addictive Behaviors. 2007; 32:1054–1065. [PubMed: 16934413]

Hussong AM, Chassin L. The stress-negative affect model of adolescent alcohol use: Disaggregating negative affect. Journal of Studies on Alcohol. 1994; 55:707–718. [PubMed: 7861800]

Jackson KM, O'Neill SE, Sher KJ. Characterizing alcohol dependence: Transitions during young and middle adulthood. Experimental and Clinical Psychopharmacology. 2006; 14:228–244. [PubMed: 16756427]

Jackson, KM.; Sher, KJ.; Park, A. Drinking among college students. Consumption and consequences. In: Galanter, M., editor. Recent developments in alcoholism, Vol. 17: Alcohol problems in adolescents and young adults. Vol. 17. New York, NY: Springer; 2005. p. 85-117.

Jahng S, Solhan MB, Tomko RL, Wood PK, Piasecki TM, Trull TJ. Affect and alcohol use: An ecological momentary assessment study of outpatients with borderline personality disorder. Journal of Abnormal Psychology. 2011a; 120:572–584. [PubMed: 21823761]

Jahng S, Trull TJ, Wood PK, Tragesser SL, Tomko R, Grant JD, Sher KJ. Distinguishing general and specific personality disorder features and implications for substance dependence comorbidity. Journal of Abnormal Psychology. 2011b; 120:656–669. [PubMed: 21604829]

Jahng S, Wood PK, Trull TJ. Analysis of affective instability in ecological momentary assessment: Indices using successive difference and group comparison via multilevel modeling. Psychological Methods. 2008; 13:354–375. [PubMed: 19071999]

Jochman, KA.; Fromme, K.; Scheier, PL. Maturing out of substance use: The other side of etiology. In: Scheier, L., editor. Handbook of drug use etiology: Theory, methods, and empirical findings. Washington, DC: American Psychological Association; 2010. p. 565-578.

Kassel, JD.; Hussong, AM.; Wardle, MC.; Veilleux, JC.; Heinz, A.; Greenstein, JE.; Evatt, DP. Affective influences in drug use etiology. In: Scheier, L., editor. Handbook of drug use etiology: Theory, methods, and empirical findings. Washington, DC: American Psychological Association; 2010. p. 183-205.

Kassel, JD.; Veilleux, JC. Introduction: The complex interplay between substance abuse and emotion. In: Kassel, JD., editor. Substance abuse and emotion. Washington, DC: American Psychological Association; 2010. p. 3-12.

Knight JR, Wechsler H, Kuo M, Seibring M, Weitzman ER, Schuckit MA. Alcohol abuse and dependence among U.S. college students. Journal of Studies on Alcohol. 2002; 63:263–270. [PubMed: 12086126]

Lambert D. Zero-inflated poisson regression, with an application to defects in manufacturing. Technometrics. 1992; 34:1–14.

Larsen, RJ.; Diener, E. Promises and problems with the circumplex model of emotion. In: Clark, MS., editor. Emotion. London, UK: Sage; 1992. p. 25-59.

Larson R, Csikszentmihalyi M, Graef R. Mood variability and the psychosocial adjustment of adolescents. Journal of Youth and Adolescence. 1980; 9:469–490. [PubMed: 24318310]

Lieberman MD. Social cognitive neuroscience: A review of core processes. Annual Review of Psychology. 2007; 58:259–289.

Liu RT, Alloy LB. Stress generation in depression: A systematic review of the empirical literature and recommendations for future study. Clinical Psychology Review. 2010; 30:582–593. [PubMed: 20478648]

Long, JS.; Freese, J. Regression models for categorical dependent variables using Stata. 2nd. College Station, TX: Stata Press; 2006.

Lüdtke O, Marsh HW, Robitzsch A, Trautwein U, Asparouhov T, Muthen B. The multilevel latent covariate model: A new, more reliable approach to group-level effects in contextual studies. Psychological Methods. 2008; 13:203–229. [PubMed: 18778152]

Lyubomirsky S, King L, Diener E. The benefits of frequent positive affect: Does happiness lead to success? Psychological Bulletin. 2005; 131:803–855. [PubMed: 16351326]

Merz EL, Roesch SC. Modeling trait and state variation using multilevel factor analysis with PANAS daily diary data. Journal of Research in Personality. 2011; 45:2–9. [PubMed: 21516166]

Mezquita L, Stewart SH, Ruiperez Å. Big-five personality domains predict internal drinking motives in young adults. Personality and Individual Differences. 2010; 49:240–245.

Mohr CD, Armeli S, Tennen H, Carney MA, Affleck G, Hromi A. Daily interpersonal experiences, context, and alcohol consumption: Crying in your beer and toasting good times. Journal of Personality and Social Psychology. 2001; 80:489–500. [PubMed: 11300581]

Mohr CD, Armeli S, Tennen H, Temple M, Todd M, Clark J, Carney MA. Moving beyond the keg party: A daily process study of college student drinking motivations. Psychology of Addictive Behaviors. 2005; 19:392–403. [PubMed: 16366811]

Mohr, C.; Armeli, S.; Tennen, H.; Todd, M. The complexities of modeling mood-drinking relationships: Lessons learned from daily process research. In: Kassel, JD.; Kassel, JD., editors. Substance abuse and emotion. Washington, DC: American Psychological Association; 2010. p. 189-216.

Murphy JG, Correia CJ, Barnett NP. Behavioral economic approaches to reduce college student drinking. Addictive Behaviors. 2007; 32:2573–2585. [PubMed: 17600631]

Muthén, LK.; Muthén, BO. Mplus statistical modeling software: Release. Vol. 7. Los Angeles, CA: Muthén & Muthén; 2012.

Neal DJ, Fromme K. Event-level covariation of alcohol intoxication and behavioral risks during the first year of college. Journal of Consulting and Clinical Psychology. 2007; 75:294–306. [PubMed: 17469887]

Neighbors C, Atkins DC, Lewis MA, Lee CM, Kaysen D, Mittmann A, Rodriguez LM. Event-specific drinking among college students. Psychology of Addictive Behaviors. 2011; 25:702–707. [PubMed: 21639597]

Neighbors C, Walters ST, Lee CM, Vader AM, Vehige T, Szigethy T, DeJong W. Event-specific prevention: Addressing college student drinking during known windows of risk. Addictive Behaviors. 2007; 32:2667–2680. [PubMed: 17616260]

Oliver MNI, Simons JS. The affective lability scales: Development of a Short-form measure. Personality and Individual Differences. 2004; 37:1279–1288.

Park CL, Armeli S, Tennen H. The daily stress and coping process and alcohol use among college students. Journal of Studies on Alcohol. 2004; 65:126–135. [PubMed: 15000512]

Piasecki TM, Jahng S, Wood PK, Robertson BM, Epler AJ, Cronk NJ, Sher KJ. The subjective effects of alcohol-tobacco co-use: An ecological momentary assessment investigation. Journal of Abnormal Psychology. 2011; 120:557–571. [PubMed: 21443289]

Preacher KJ, Zhang Z, Zyphur MJ. Alternative methods for assessing mediation in multilevel data: The advantages of multilevel SEM. Structural Equation Modeling. 2011; 18:161–182.

Preacher KJ, Zyphur MJ, Zhang Z. A general multilevel SEM framework for assessing multilevel mediation. Psychological Methods. 2010; 15:209–233. [PubMed: 20822249]

Read JP, Merrill JE, Kahler CW, Strong DR. Predicting functional outcomes among college drinkers: Reliability and predictive validity of the Young Adult Alcohol Consequences Questionnaire. Addictive Behaviors. 2007; 32:2597–2610. [PubMed: 17706888]

Rothbart, MK.; Sheese, BE. Temperament and Emotional Regulation. In: Gross, JJ., editor. Handbook of emotion regulation. New York, NY: Guilford Press; 2007. p. 331-350.

Sanchez-Craig M, Wilkinson DA, Davila R. Empirically based guidelines for moderate drinking: 1-year results from three studies with problem drinkers. American Journal of Public Health. 1995; 85:823–828. [PubMed: 7762717]

Schulenberg JE, Maggs JL. A developmental perspective on alcohol use and heavy drinking during adolescence and the transition to young adulthood. Journal of Studies on Alcohol, Suppl. 2002:54–70.

Shiffman S. Ecological momentary assessment (EMA) in studies of substance use. Psychological Assessment. 2009; 21:486–497. [PubMed: 19947783]

Simons JS, Carey KB. Risk and vulnerability for marijuana use problems: The role of affect dysregulation. Psychology of Addictive Behaviors. 2002; 16:72–75. [PubMed: 11934090]

Simons JS, Carey KB. An affective and cognitive model of marijuana and alcohol problems. Addictive Behaviors. 2006; 31:1578–1592. [PubMed: 16426771]

Simons JS, Carey KB, Wills TA. Alcohol abuse and dependence symptoms: A multidimensional model of common and specific etiology. Psychology of Addictive Behaviors. 2009; 23:415–427. [PubMed: 19769426]

Simons JS, Dvorak RD, Batien BD, Wray TB. Event-level associations between affect, alcohol intoxication, and acute dependence symptoms: Effects of urgency, self-control, and drinking experience. Addictive Behaviors. 2010; 35:1045–1053. [PubMed: 20685044]

Simons JS, Gaher RM, Correia CJ, Hansen CL, Christopher MS. An affective-motivational model of marijuana and alcohol problems among college students. Psychology of Addictive Behaviors. 2005a; 19:326–334. [PubMed: 16187813]

Simons JS, Gaher RM, Oliver MNI, Bush JA, Palmer MA. An experience sampling study of associations between affect and alcohol use and problems among college students. Journal of Studies on Alcohol. 2005b; 66:459–469. [PubMed: 16240553]

Simons JS, Neal DJ, Gaher RM. Risk for marijuana-related problems among college students: An application of zero-inflated negative binomial regression. The American Journal of Drug and Alcohol Abuse. 2006; 32:41–53. [PubMed: 16450642]

Simons JS, Oliver MNI, Gaher RM, Ebel G, Brummels P. Methamphetamine and alcohol abuse and dependence symptoms: Associations with affect lability and impulsivity in a rural treatment population. Addictive Behaviors. 2005c; 30:1370–1381. [PubMed: 16022933]

Sliwinski MJ. Measurement-burst designs for social health research. Social and Personality Psychology Compass. 2008; 2:245–261.

Stone AA, Shiffman S. Capturing momentary, self-report data: A proposal for reporting guidelines. Annals of Behavioral Medicine. 2002; 24:236–243. [PubMed: 12173681]

Substance Abuse and Mental Health Service Administration. Results from the 2009 National Survey on Drug Use and Health: Volume I. Summary of national findings. Rockville, MD: Office of Applied Studies, NSDUH Series H-38A, HHS Publication N. SMA 10–4586; 2010.

Substance Abuse and Mental Health Service Administration. Results from the 2010 National Survey on Drug Use and Health: Detailed tables. Rockville, MD: 2011.

Swendsen JD, Tennen H, Carney MA, Affleck G, Willard A, Hromi A. Mood and alcohol consumption: An experience sampling test of the self-medication hypothesis. Journal of Abnormal Psychology. 2000; 109:198–204. [PubMed: 10895557]

Tice DM, Bratslavsky E, Baumeister RF. Emotional distress regulation takes precedence over impulse control: If you feel bad, do it. Journal of Personality and Social Psychology. 2001; 80:53–67. [PubMed: 11195891]

Trull TJ, Solhan MB, Tragesser SL, Jahng S, Wood PK, Piasecki TM, Watson D. Affective instability: Measuring a core feature of borderline personality disorder with ecological momentary assessment. Journal of Abnormal Psychology. 2008; 117:647–661. [PubMed: 18729616]

Wardell JD, Read JP, Colder CR, Merrill JE. Positive alcohol expectancies mediate the influence of the behavioral activation system on alcohol use: A prospective path analysis. Addictive Behaviors. 2012; 37:435–443. [PubMed: 22209025]

Watson, D.; Clark, LA. Manual for the Positive and Negative Affect Schedule (Expanded Form). Iowa City, IA: University of Iowa; 1994.

Weinstein SM, Mermelstein R, Shiffman S, Flay B. Mood variability and cigarette smoking escalation among adolescents. Psychology of Addictive Behaviors. 2008; 22:504–513. [PubMed: 19071975]

Weiss HM, Beal DJ, Lucy SL, MacDermid SM. Constructing EMA studies with PMAT: The Purdue momentary assessment tool user's manual. 2004 Retrieved from http://www.mfri.purdue.edu/pages/PMAT/pmatusermanual.pdf.

Wiers RW, Bartholow BD, van den Wildenberg E, Thush C, Engels RCME, Sher KJ, Stacy AW. Automatic and controlled processes and the development of addictive behaviors in adolescents: A review and a model. Pharmacology, Biochemistry and Behavior. 2007; 86:263–283.

Wiers RW, Gladwin TE, Hofmann W, Salemink E, Ridderinkhof KR. Cognitive bias modification and cognitive control training in addiction and related psychopathology: Mechanisms, clinical perspectives, and ways forward. Clinical Psychological Science. 2013; 1:192–212.

Wills, TA.; Ainette, MG. Temperament, self-control, and adolescent substance use: A two-factor model of etiological processes. In: Scheier, PL.; Scheier, PL., editors. Handbook of drug use etiology: Theory, methods, and empirical findings. Washington, DC: American Psychological Association; 2010. p. 127-146.

Wills TA, Bantum EO, Pokhrel P, Maddock JE, Ainette MG, Morehouse E, Fenster B. A dual-process model of early substance use: Tests in two diverse populations of adolescents. Health Psychology. 2013; 32:533–542. [PubMed: 23646836]

Wills TA, Pokhrel P, Morehouse E, Fenster B. Behavioral and emotional regulation and adolescent substance use problems: A test of moderation effects in a dual-process model. Psychology of Addictive Behaviors. 2011; 25:279–292. [PubMed: 21443302]

Wills TA, Sandy JM, Shinar O, Yaeger A. Contributions of positive and negative affect to adolescent substance use: Test of a bidimensional model in a longitudinal study. Psychology of Addictive Behaviors. 1999; 13:327–338.

Wills, TA.; Shiffman, S. Coping and substance use: A conceptual framework. In: Shiffman, S.; Wills, T., editors. Coping and substance use. Orlando, FL: Academic Press; 1985. p. 3-24.

Wills, TA.; Simons, JS.; Gibbons, FX. Self-control and substance use prevention: A translational analysis. In: Scheier, L., editor. Handbook of drug prevention. Washington, DC: American Psychological Association; (in press)

Wills TA, Walker C, Mendoza D, Ainette MG. Behavioral and emotional self-control: Relations to substance use in samples of middle and high school students. Psychology of Addictive Behaviors. 2006; 20:265–278. [PubMed: 16938064]

Wray, TB.; Reed, RN.; Hunsaker, R.; Finn, JR.; Simons, JS. How much did you drink on Friday? Comparison of three self-report measures with transdermal alcohol assessment. Paper presented at the Annual Convention of the American Psychological Association; Orlando, Fl. 2012.

Yacubian J, Buchel C. The genetic basis of individual differences in reward processing and the link to addictive behavior and social cognition. Neuroscience. 2009; 164:55–71. [PubMed: 19446009]

Appendix

Description of Multilevel Model Equations

The hypothesized Level 1 model for dependence (covariates are omitted for simplicity) is expressed as follows:

$$\text{Dependence}_{ij} = \exp(\beta_{0j} + \beta_1(\text{drinks}_{\text{wij}}) + \beta_2(\text{negative affect}_{\text{wij}}) + 1^{*}\log\left[\text{exposure}_{\text{ij}}\right] + r_{\text{ij}}) \quad (1)$$

where Dependence is person j’s alcohol dependence symptoms on day *i*, β_{0j} is the random intercept, the person’s predicted level of dependence (i.e., when all other time varying variables are at the person mean, because variables are person-centered), β_1 and β_2 are the estimated path coefficients, drinks_{wij} and negative affect_{wij} are the MSEM estimated latent variables used on the within level, and r_{ij} is a random residual component. Thus, this model accounts for the within-person direct effect of drinking and negative affect on dependence symptoms. Exposure is the number of completed assessments on day i for person j, which controls for different response rates (Long & Freese, 2006).

Drinks_{wij} at Level 1 is a zero-inflated negative binomial distribution and the two-part model is parameterized as follows:

$$\text{Probability of zero drinks}_{wij}=\exp(\beta_{3j}+\beta_4(\text{negative affect}_{wij})+\beta_5(\text{positive affect}_{wij})+r_{ij})/(1+\exp(\beta_{3j}+\beta_4(\text{negative affect}_{wij})+\beta_5(\text{positive affect}_{wij})+r_{ij})), \quad (2)$$

where β_{3j} is the random intercept of the prediction of zero-inflation (i.e., abstaining) for person j. That is, the person's expected value across the study (i.e., when all other time varying variables are at the person's mean).

$$\text{Count of drinks}_{wij}=\exp(\beta_{6j}+\beta_7(\text{negative affect}_{wij})+\beta_8(\text{positive affect}_{wij})+1*\log[\text{exposure}_{ij}]+r_{ij}) \quad (3)$$

where β_{6j} is a random intercept of the predicted count of drinks (i.e., consumption) on days when not abstaining for person j.

Positive affect_{wij} and negative affect_{wij} are continuous MSEM estimated latent variables used on the within level and are parameterized as follows:

$$\text{Negative affect}_{wij}=\beta_{9j}+\beta_{10}(\text{Monday}_{ij})+\beta_{11}(\text{Tuesday}_{ij})+\beta_{12}(\text{Wednesday}_{ij})+\beta_{13}(\text{Thursday}_{ij})+\beta_{14}(\text{Friday}_{ij})+\beta_{15}(\text{Saturday}_{ij})+\beta_{16}(\text{elapsed days}_{ij})+\beta_{17}(\text{semester}_{ij})+r_{ij} \quad (4)$$

$$\text{Positive affect}_{wij}=\beta_{18j}+\beta_{19}(\text{Monday}_{ij})+\beta_{20}(\text{Tuesday}_{ij})+\beta_{21}(\text{Wednesday}_{ij})+\beta_{22}(\text{Thursday}_{ij})+\beta_{23}(\text{Friday}_{ij})+\beta_{24}(\text{Saturday}_{ij})+\beta_{25}(\text{elapsed days}_{ij})+\beta_{26}(\text{semester}_{ij})+r_{ij} \quad (5)$$

Here, β_{9j} and β_{18j} are the person's estimated mean level of negative and positive affect, respectively. That is, the expected value when all other time varying variables are at the person mean.

The hypothesized Level 2 model is expressed as follows:

$$\text{Dependence symptoms}_j=\beta_{0j}=\gamma_{00}+\gamma_{01}(\text{gender})+\gamma_{02}(\text{likelihood of abstaining}_{bj})+\gamma_{03}(\text{consumption}_{bj})+\gamma_{04}(\text{negative affect}_{bj})+\gamma_{05}(\text{lability}_j)+u_{0j} \quad (6)$$

Here, likelihood of abstaining_{bj}, consumption_{bj}, and negative affect_{bj} are the latent between-person covariates estimated by the MSEM model. Lability and gender are observed variables. Dependence symptoms_j is the estimated mean level of dependence symptoms for person j across the study. u_{0j} is a random effect. Equations for Level 2 drinking and affect outcomes are parameterized as follows:

$$\text{Likelihood of abstaining}_{bj}=\beta_{3j}=\gamma_{30}+\gamma_{31}(\text{gender}_j)+\gamma_{32}(\text{age}_j)+\gamma_{33}(\text{positive affect}_{bj})+\gamma_{34}(\text{negative affect}_{bj})+\gamma_{35}(\text{lability}_j)+\gamma_{36}(\text{time in study}_j)+u_{3j} \quad (7)$$

$$\text{Consumption}_{bj}=\beta_{6j}=\gamma_{60}+\gamma_{61}(\text{gender}_j)+\gamma_{62}(\text{time in study}_j)+\gamma_{63}(\text{positive affect}_{bj})+\gamma_{64}(\text{negative affect}_{bj})+\gamma_{65}(\text{lability}_j)+u_{6j} \quad (8)$$

$$\text{Negative affect}_{\text{bj}}=\beta_{9\text{j}}=\gamma_{90}+\gamma_{91}(\text{gender}_{\text{j}})+\gamma_{92}(\text{lability}_{\text{j}})+u_{9\text{j}} \quad (9)$$

$$\text{Positive affect}_{\text{bj}}=\beta_{18\text{j}}=\gamma_{180}+\gamma_{181}(\text{gender}_{\text{j}})+\gamma_{182}(\text{university}_{\text{j}})+\gamma_{183}(\text{lability}_{\text{j}})+u_{18\text{j}} \quad (10)$$

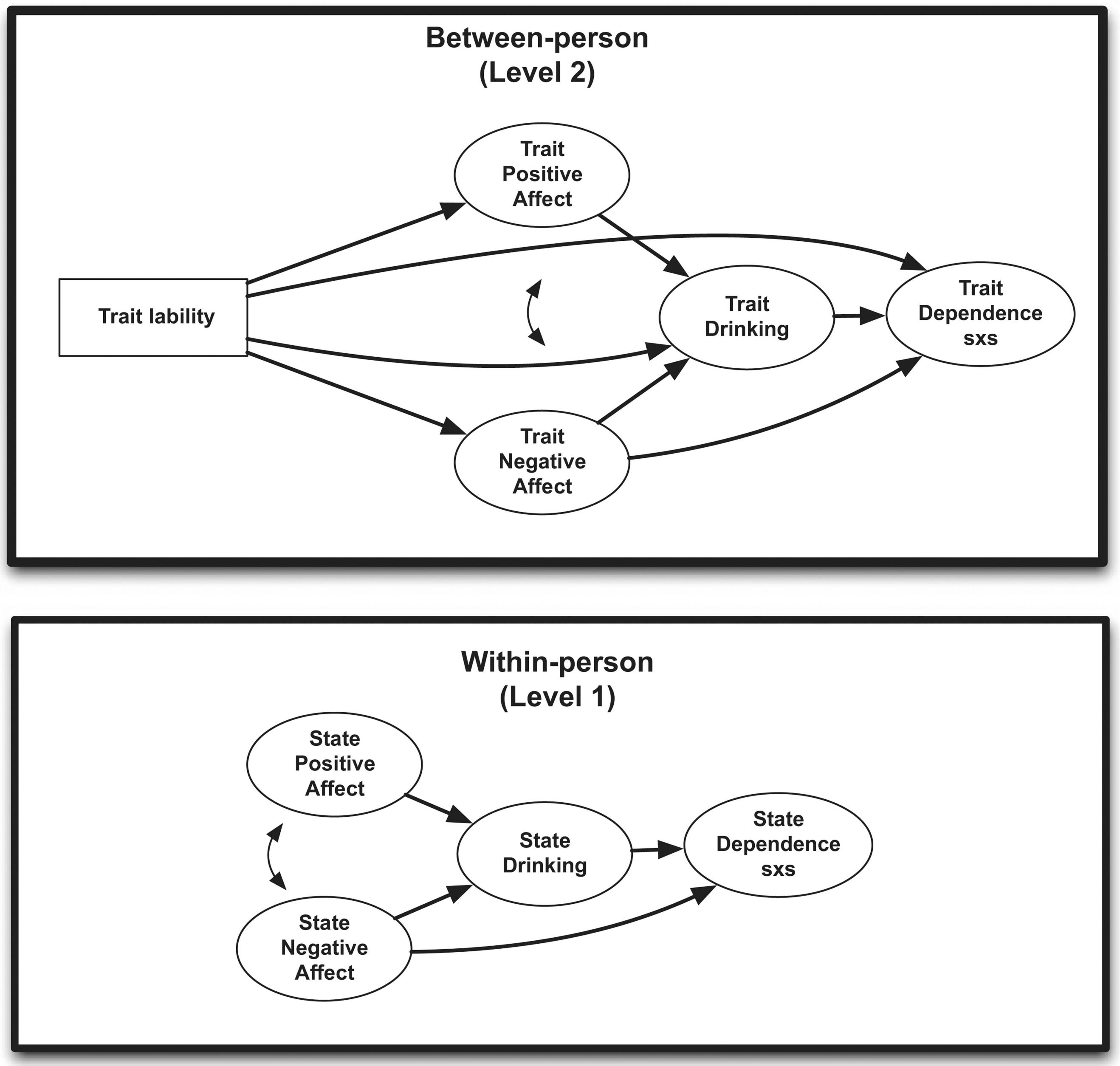

Figure 1.
Conceptual model of hypothesized between- and within-person relationships.

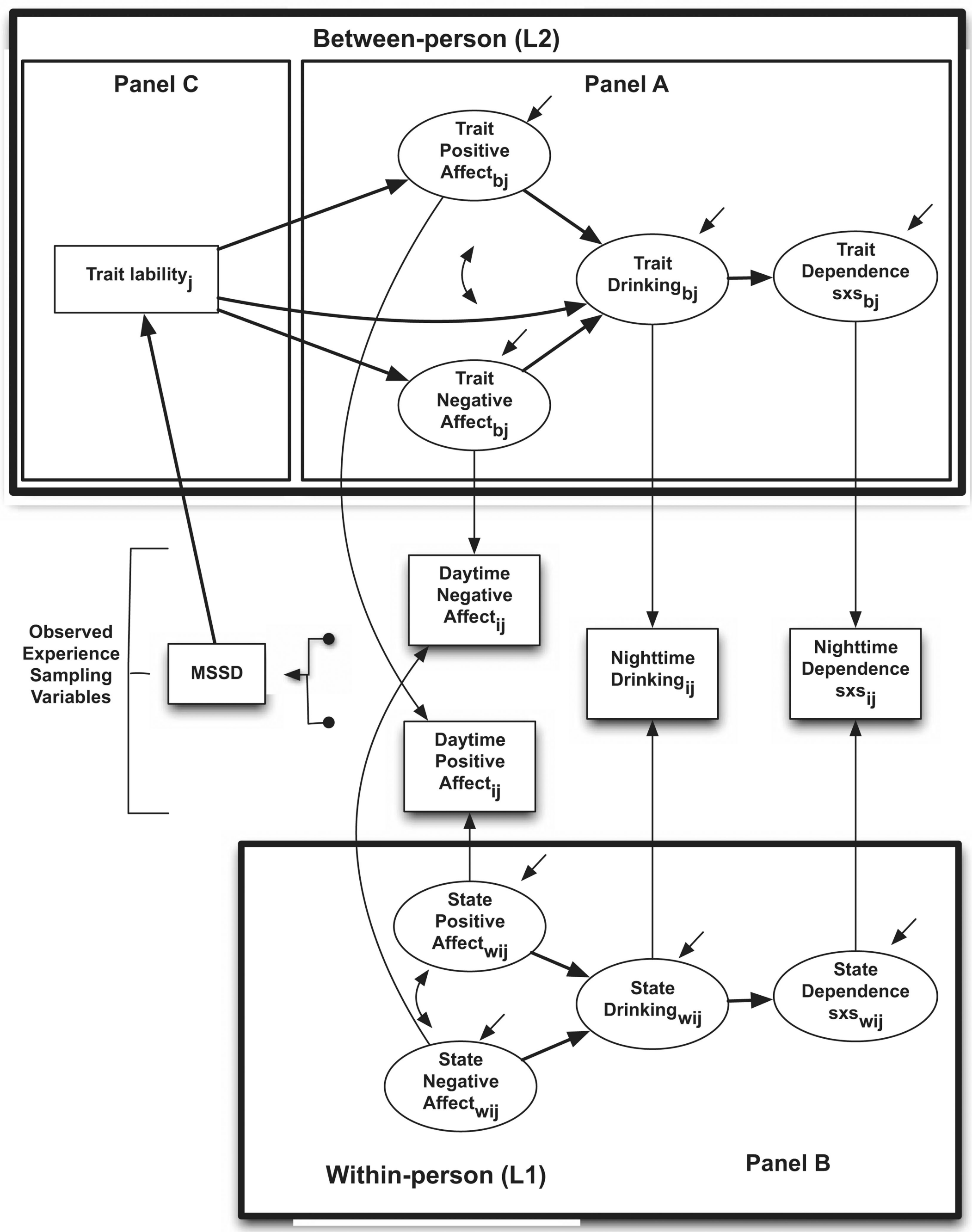

Figure 2.

Conceptual MSEM depicting the within- and between-person effects. The figure illustrates that repeated measures of affect and alcohol outcomes are decomposed into latent trait (between) and state (within) components. The between-person lability variable is also estimated from the repeated measures data. For clarity, a simplified model omitting additional hypothesized effects and covariates is depicted.

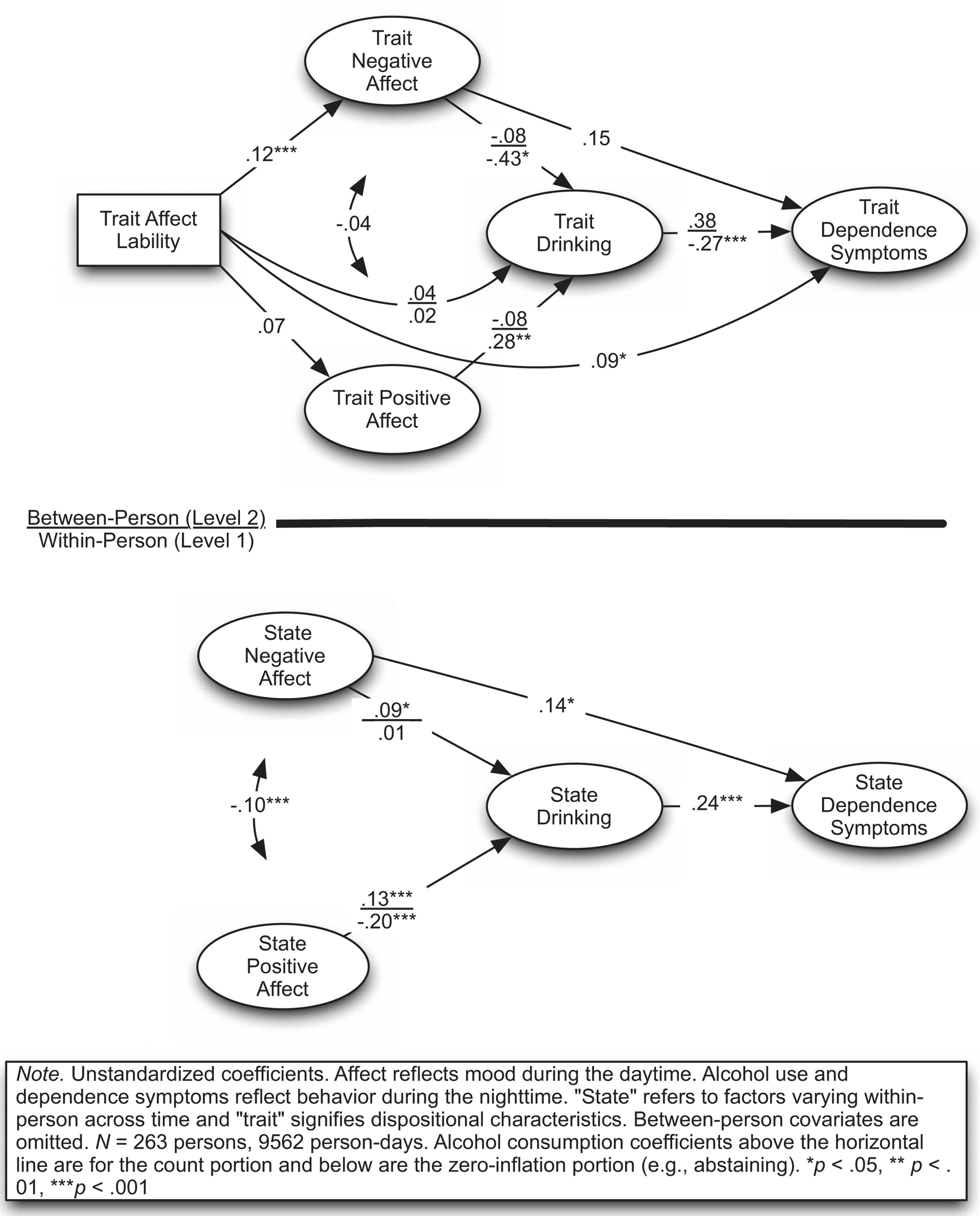

Figure 3.

Multilevel structural model depicting key within-person and between-person effects.

Note. Unstandardized coefficients. Affect reflects mood during the daytime. Alcohol use and dependence symptoms reflect behavior during the nighttime. "State" refers to factors varying within-person across time and "trait" signifies dispositional characteristics. Between-person covariates are omitted. N = 263 persons, 9562 person-days. Alcohol consumption coefficients above the horizontal line are for the count portion and below are the zero-inflation portion (e.g., abstaining). *$p < .05$, ** $p < .01$, ***$p < .001$

Table 1

Descriptive Statistics

Variable	Type/Source	*M* (*SD*)	Range	Skew
Negative affect	State[a]/ESM	1.49 (0.63)	1–6.89	2.23
Positive affect	State[a]/ESM	2.93 (1.24)	1–7.00	0.55
Alcohol consumption	State[a]/ESM	1.23 (2.93)	0–28	3.48
Dependence symptoms	State[a]/ESM	0.50 (1.37)	0–16	4.12
Affect lability[b]	Trait[b]/ESM	2.19 (1.39)	0.00–6.91	1.21
Gender	Trait/Baseline		115M/148W	
Age	Trait/Baseline	19.88 (1.37)	18–27	1.31

Note. n = 263 for gender, age, and lability variables. Observed ns range from 8815–9240 for the L1 affect and drinking variables.

[a]The repeated measures are decomposed into latent within- (state) and between- (trait) variables in the model (see Figure 2).

[b]Trait variables is estimated from the individual's pattern of emotion assessments across the study period.

Table 2

Correlations Between L2 Variables

Variable	1	2	3	4	5	6	7	8	9	10
1. Abstinent days	—									
2. Alcohol consumption	−.28	—								
3. Dependence symptoms	−.37	.25	—							
4. Trait negative affect	−.12	−.06	.22	—						
5. Trait positive affect	.23	−.13	−.10	−.07	—					
6. Affect lability	.02	.07	.24	.45	.12	—				
7. Gender	−.23	.29	−.10	−.15	.09	−.09	—			
8. Age	−.27	−.08	.08	−.08	.07	−.09	.09	—		
9. University	.04	.12	−.08	−.02	.16	.07	.18	−.28	—	
10. Time in study	.17	−.19	−.00	.08	.01	−.00	−.06	−.06	.14	—

Note. $n = 263$. $r > |.13|$, $p < .05$. Gender is coded 0 = *women*, 1 = *men*. Abstinent days reflect proportion of days abstinent and alcohol consumption reflects number of drinks on expected drinking days. Time in study is a L2 indicator of length of time retained in study.

Table 3

Summary of Main Effect Model Building Steps

Model	AIC BIC	Wald test of parameters	Summary of focal significant effects
1. Base model. Affect and lability indirectly associated with dependence via alcohol use.	77644.81	—	Lability -> +TNA
	78246.72		TPA -> + Abstaining
			TNA -> −Abstaining
			PA -> + Consumption
			PA -> −Abstaining
			NA -> + Consumption
2. Test direct effects of NA to dependence at L1 and L2	77629.35	$\chi^2(2) = 11.19$	TNA -> + Dependence
	78245.59	$p = .0037$	NA -> + Dependence
3. Add L2 lability direct effect to dependence	77626.86	$\chi^2(1) = 5.20$	Lability -> + Dependence
	78250.27	$p = .0226$	

Note. In Model 1 and 2, L2 (between person) effects are above, and L1 (within-person) effects below, the line. The remaining models are all L2 effects. The "+" and "−" signs indicate the sign of the coefficient. TPA = Trait Positive affect; TNA = Trait Negative Affect; NA = L1 Negative Affect; PA = L1 Positive Affect.

Table 4

Lability and Positive and Negative Affect: Within- and Between-Person Effects

	Lability			Positive affect			Negative affect		
Predictors	***b***	***SE***	***p***	***b***	***SE***	***p***	***b***	***SE***	***p***
Intercept	0.04	0.09	.649	2.91	0.05	<.001	1.49	0.02	<.001
Gender	−0.26	0.17	.133	0.12	0.11	.257	−0.09	0.05	.064
Lability				0.07	0.04	.076	0.12	0.02	<.001
University				0.26	0.11	.021			
Time covariates									
Monday				**0.02**	**0.04**	**.607**	**0.09**	**0.02**	**<.001**
Tuesday				**−0.02**	**0.04**	**.624**	**0.10**	**0.02**	**<.001**
Wednesday				**0.03**	**0.04**	**.404**	**0.10**	**0.02**	**<.001**
Thursday				**0.08**	**0.04**	**.039**	**0.07**	**0.02**	**<.001**
Friday				**0.20**	**0.04**	**<.001**	**0.04**	**0.02**	**.049**
Saturday				**0.17**	**0.04**	**<.001**	**−0.03**	**0.02**	**.079**
Elapsed days				**−0.07**	**0.02**	**<.001**	**−0.03**	**0.01**	**<.001**
Semester				**0.01**	**0.04**	**.800**	**0.04**	**0.02**	**.010**

Note. L1 $n = 9562$, L2 $n = 263$. Gender is coded 0 = *women*, 1 = *men*. Elapsed days refers to the days elapsed since the person initiated the study (L1, time varying). Semester is coded 0 = *spring*, 1 = *fall*. Between-person effects are regular font. Within-person effects are bold font.

Table 5

Abstaining, Consumption, and Dependence Symptoms: Within- and Between-Person Effects

	Outcomes								
	Abstaining likelihood			Consumption			Dep. Symptoms		
Predictors	***b***	***SE***	***p***	***b***	***SE***	***p***	***b***	***SE***	***p***
Intercept	1.55	0.17	<.001	−0.65	0.09	<.001	−3.14	0.11	<.001
Gender	−0.45	0.12	<.001	0.22	0.06	<.001	−0.30	0.10	.002
Trait abstaining							−0.27	0.08	.001
Trait alcohol consumption							0.38	0.22	.092
Trait positive affect	0.28	0.09	.002	−0.08	0.05	.085			
Trait negative affect	−0.43	0.20	.028	−0.08	0.10	.430	0.15	0.17	.391
Lability	0.02	0.05	.770	0.04	0.03	.115	0.09	0.04	.023
Age	−0.19	0.05	<.001						
Time in study	0.08	0.04	.054	−0.04	0.02	.060			
State alc. consumption							**0.24**	**0.01**	**<.001**
State pos. affect	**−0.20**	**0.04**	**<.001**	**0.13**	**0.02**	**<.001**			
State neg. affect	**0.01**	**0.07**	**.892**	**0.09**	**0.04**	**.014**	**0.14**	**0.06**	**.016**
Time covariates									
Monday	**0.28**	**0.13**	**.029**	**−0.06**	**0.11**	**.600**	**−0.18**	**0.12**	**.123**
Tuesday	**0.21**	**0.14**	**.121**	**−0.15**	**0.10**	**.138**	**−0.29**	**0.14**	**.032**
Wednesday	**−0.12**	**0.13**	**.384**	**0.01**	**0.10**	**.956**	**0.27**	**0.13**	**.034**
Thursday	**−0.96**	**0.12**	**<.001**	**0.08**	**0.08**	**.341**	**0.48**	**0.12**	**<.001**
Friday	**−1.73**	**0.12**	**<.001**	**0.43**	**0.08**	**<.001**	**0.97**	**0.12**	**<.001**
Saturday	**−1.55**	**0.12**	**<.001**	**0.33**	**0.08**	**<.001**	**0.98**	**0.11**	**<.001**
Elapsed days	**0.04**	**0.03**	**.214**	**−0.02**	**0.02**	**.116**	**−0.05**	**0.03**	**.110**
Semester	**−0.19**	**0.08**	**.021**	**0.10**	**0.05**	**.026**	**−0.05**	**0.08**	**.530**

Note. L1 $n = 9562$, L2 $n = 263$. Gender is coded 0 = *women*, 1 = *men*. Time in study refers to the length of time the person participated (L2). Elapsed days refers to the days elapsed since the person initiated the study (L1). Semester is coded 0 = *spring*, 1 = *fall*. Between-person effects are regular font. Within-person effects are bold font.

Table 6

Summary of Main Hypotheses and Findings

Positive affect

Between-person

1 Trait positive affect will be inversely associated with alcohol consumption. *Hypothesis supported for proportion of drinking days and marginally for consumption amount on drinking days.*

2 Trait positive affect will be indirectly associated with fewer dependence symptoms. *Trait positive affect was indirectly associated with dependence symptoms as hypothesized.*

Within-person

1 Positive affect during the day will be associated with more alcohol consumption that night. *Hypothesis supported. Positive affect was associated with a higher likelihood of drinking and higher consumption on drinking nights.*

Negative affect

Between-person

1 Trait negative affect will be associated with higher rates of alcohol consumption. *Hypothesis partially supported. Trait negative affect was associated with a higher proportion of drinking days but not higher consumption on drinking days.*

2 Trait negative affect will be indirectly associated with more dependence symptoms. *Trait negative affect was indirectly associated with dependence symptoms via proportion of drinking days as hypothesized.*

3 Trait negative affect will be directly associated with dependence symptoms over and above drinking. *Hypothesis not supported.*

Within-person

1 Negative affect during the day will be associated with more alcohol consumption that night. *Hypothesis partially supported. Negative affect predicted higher alcohol consumption on drinking nights, but not the likelihood of drinking.*

2 Negative affect will be directly associated with dependence symptoms over and above alcohol consumption. *Hypothesis supported.*

Affect lability

1 Lability will be associated with higher negative affect. *Hypothesis supported.*

2 Lability will be indirectly associated with dependence symptoms via negative affect. *Hypothesized indirect effect was marginally significant.*

3 Lability will be directly associated with dependence symptoms over and above drinking. *Hypothesis supported.*

Summary

At the daily level, positive affect is associated with increases in alcohol use, however, dispositional positive affect confers decreased risk for alcohol dependence. State negative affect and trait affect lability confer increased risk for symptoms of alcohol dependence.