Brain and Neuroscience Advances

Brain and Neuroscience Advances
Volume 6: 1–12

Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/23982128221079556
journals.sagepub.com/home/bna
SAGE

No evidence for trait- and state-level urgency moderating the daily association between negative affect and subsequent alcohol use in two college samples

Jonas Dora, Megan E. Schultz, Yuichi Shoda, Christine M. Lee and Kevin M. King

Abstract

It remains unclear whether the negative reinforcement pathway to problematic drinking exists, and if so, for whom. One idea that has received some support recently is that people who tend to act impulsively in response to negative emotions (i.e. people high in negative urgency) may specifically respond to negative affect with increased alcohol consumption. We tested this idea in a preregistered secondary data analysis of two ecological momentary assessment studies using college samples. Participants (N = 226) reported on their current affective state multiple times per day and also the following morning reported alcohol use of the previous night. We assessed urgency both at baseline and during the momentary affect assessments. Results from our Bayesian model comparison procedure, which penalises increasing model complexity, indicate that no combination of the variables of interest (negative affect, urgency, and the respective interactions) outperformed a baseline model that included two known demographic predictors of alcohol use. A non-preregistered exploratory analysis provided some evidence for the effect of daily positive affect, positive urgency, as well as their interaction on subsequent alcohol use. Taken together, our results suggest that college students' drinking may be better described by a positive rather than negative reinforcement cycle.

Keywords

Affect, alcohol use, urgency, negative reinforcement, ecological momentary assessment

Received: 12 July 2021; accepted: 22 January 2022

Multiple theoretical models proposed in the past six decades converge on the idea that people consume alcohol to cope with negative affect (Cloninger, 1987; Conger, 1956; Cooper et al., 1995; Greeley and Oei, 1999; Hussong et al., 2011; Khantzian, 1990; Wills and Filer, 1996). This ties in with broader theoretical work that assumes people are more likely to engage in risky and maladaptive behaviours (such as substance abuse) when they experience negative emotions (Baker et al., 2004; Grant et al., 2003; Kotov et al., 2010; Malouff et al., 2007).

However, the evidence from ecologically relevant studies, where both negative affect and alcohol use are sampled in vivo during the course of daily life, is relatively poor. Dozens of ecological momentary assessment (EMA) or daily studies have measured negative affect and alcohol use (Ehrenberg et al., 2016; Hussong et al., 2001; Simons et al., 2005). Although some earlier studies reported the expected association (Armeli et al., 2000; Park et al., 2004; Simons et al., 2005), more recent studies have reported predominantly null associations (Dvorak et al., 2018; Ehrenberg et al., 2016; O'Donnell et al., 2019; Stevenson et al., 2019). For studies that found daily associations between increased negative affect and alcohol use, heavy or hazardous drinking levels was often an inclusion criteria (Armeli et al., 2000; Mohr et al., 2008; Simons et al., 2005). Studies that did not find effects typically had fewer drinking inclusion criteria ranging from once a month to twice a week (Dvorak et al., 2018; O'Donnell et al., 2019; Stevenson et al., 2019; Waddell et al., 2021), which may suggest that this effect is more likely to be found among those engaging in heavy or hazardous drinking. Furthermore, these studies show considerable heterogeneity in the number and kind of items used to assess negative affect (Dvorak et al., 2014; Mohr et al., 2013) as well as the data analytic strategy (O'Donnell et al., 2019; Rankin and Maggs, 2006). Regardless, the literature has produced inconsistent evidence for a temporal effect of negative affect on subsequent drinking.

Department of Psychology, University of Washington, Seattle, WA, USA

Corresponding authors:
Jonas Dora, Department of Psychology, University of Washington, Box 351525, Seattle, WA 98195-1525, USA.
Email: jonas.dora.psych@gmail.com

Kevin M. King, Department of Psychology, University of Washington, Box 351525, Seattle, WA 98195-1525, USA.
Email: kingkm@uw.edu

On a broader level, affective models of alcohol use assume that people try to deal with emotions by adapting their behaviour. Many studies have shown that people differ on a trait labelled 'negative urgency', which is characterised by engaging in impulsive behaviour specifically when experiencing negative affect (Cyders and Smith, 2008). The concept of negative urgency (as captured by a well-validated self-report scale; Whiteside and Lynam, 2001) seems to play an important role in the development of maladaptive behaviours that are characterised by impulsive choices, such as drinking. Indeed, negative urgency is the facet of impulsivity most strongly related to problematic alcohol use and comparable maladaptive behaviours in cross-sectional (Coskunpinar et al., 2013) and longitudinal (Riley et al., 2015; Settles et al., 2014) research. Moreover, cross-sectional and EMA studies have shown that negative urgency is associated with emotion dysregulation and negative emotions (Feil et al., 2020; King et al., 2018), suggesting it reflects broad difficulties with experiencing and regulating negative emotions.

Multiple studies have shown that individuals higher on negative urgency exhibited stronger associations between affect and a range of impulsive behaviours (e.g. Emery et al., 2014; Owens et al., 2018). Thus, it might be that only individuals who tend to behave impulsively when facing intense emotions show the proposed association between negative affect and drinking. To our knowledge, two EMA studies on alcohol use have been conducted that tested this proposed affect × urgency interaction (Bold et al., 2017; Simons et al., 2010). Simons et al. (2010) found that trait-level negative urgency moderated the effect of daily levels of anxiety (but not hostility and sadness) on nightly intoxication, which they calculated by taking the mean of the reported daily number of drinks, subjective levels of intoxication, and blood alcohol concentration (BAC) in a sample of college students. Bold et al. (2017) found that trait-level negative urgency moderated the effect of daily levels of negative affect on drinking to intoxication, which was defined as an estimated BAC of $>$ 0.08 g% in a sample of young adults enrolled in a placebo-controlled clinical trial of naltrexone. The results of both studies indicated that, as predicted, individuals reporting higher urgency showed a positive association between daytime affect and nighttime alcohol intoxication (or likelihood of drinking to intoxication), while the association was non-significant for individuals reporting lower urgency.

Thus, individual differences in urgency show early promise to potentially explain differential effects of negative affect on alcohol use. However, neither of the two studies discussed above reported an effect on the most straightforward and common outcome in the EMA literature on affect and alcohol use, which is the number of alcoholic drinks consumed. This makes it difficult to compare these two studies with the overall literature. Indeed, the theoretical literature on the negative affect hypothesis of drinking does not specify predicting whether or not individuals drink, how much they drink, or whether they drink to intoxication in response to negative affect. Thus, the first goal of this research was to quantify the evidence for a cross-level interaction between affect and trait urgency predicting the number of drinks consumed in a day.

So far, most research has focused on between-person differences in urgency (Cyders and Smith, 2008). The implication of this assumption is that some people tend to engage in impulsive behaviour when faced with negative affect, while others do not. However, there is also ample evidence for within-person differences in urgency, such that the same person differs in the extent to which they react to their experiences of negative affect with impulsive behaviour. A recent EMA study (Halvorson et al., 2021) validated a momentary measure of negative urgency derived from trait measures, providing evidence across independent samples that urgency varies within people over time. Hence, it might also be possible that within-person variation in urgency explains the within-person differences in the effect of affect on alcohol use. From this perspective, we would expect the affect–alcohol use association to show on days when participants report higher urgency, rather than only for participants who report high trait urgency at baseline. Thus, the second goal of this study was to test the affect × urgency interaction at the state level.

In summary, more than two decades of extensive EMA research have not clarified the association of experiences of negative affect and subsequent alcohol use. In this study, we fit multiple preregistered and theoretically motivated Bayesian models to quantify the conditional probability of each model in predicting alcohol use. With this approach, we attempted to identify the statistical models that have the highest accuracy in predicting alcohol use, rather than testing the presence versus absence of statistical effects. Our aim was to test whether the inclusion of different sets of predictors (daily negative affect, trait and state urgency, and their interactions) outperformed a baseline model that included two known demographic predictors of alcohol use (sex and ethnicity). This baseline model makes for a more challenging comparison as opposed to a null model including no predictors. We chose to include sex and ethnicity as these variables reliably predict differences in alcohol use (Clements, 1999), but do not exhibit such strong effects that would be unreasonable for our psychological variables of interest to compete with.

With this analysis we are able to quantify whether the addition of the affect × urgency interaction meaningfully improves the model's predictive accuracy beyond the main effects (and if so, by how much). Furthermore, in exploratory analyses, we tested how well positive affect improved our covariate-only model to predict subsequent alcohol use. Together, we aimed to identify which combination of affect-related variables optimally predicted daily alcohol use in our data.

Method

Preregistration and data availability

Our preregistration as well as data processing and analysis scripts are available on the Open Science Framework (https://osf.io/kbe2f/). While we were not able to share the raw data associated with our analyses, we uploaded the processed data together with our modelling results in the R workspace. Analyses were preregistered after data collection, but before the first author had access to the data, and before any author conducted analyses with the alcohol outcomes.

Participants and procedure

We used data from two EMA samples. A total 258 students aged 18 to 22 years, enrolled at the University of Washington, who reported drinking alcohol at least once per week filled in EMA questionnaires on 2224 EMA days (82.3% compliance). Participants were 62.4% females, 79.6% White, 22.6% Asian and Asian American, 8.4% Hispanic/Latino, 2.2% Black, and 11.9% mixed or other ethnic identities.[1]

All participants received course credit for participation. Participants in both samples first completed an in-lab baseline self-report survey, and were then trained on an EMA protocol. Participants in the first sample received three text messages including a survey link per day (randomly during the morning, midday, and evening) for ten consecutive days. Participants in the second sample received five text messages including a survey link per day (randomly during the morning, midday, afternoon, evening, and night) for eight days (Thursday to Sunday for two consecutive weeks). Surveys were sent at least 2 h apart; participants always had 1 h to complete each survey and received a reminder after 30 min. Because daily drinking episodes were the focal outcome in this study, we aggregated predictor variables at the daily level. The study protocol was approved by the local ethics review board.

For our model comparison, we had to fit our models on the exact same number of observations. Thus, we removed all days on which at least one of our variables of interest was missing (this was the case on 28.9% of days), resulting in a final dataset of 1581 EMA days by 226 participants[2] ($N_{Sample1} = 138$; $N_{Sample2} = 88$). Bayes $Factors_{10} < 1$ indicated that missingness did not differ as a function of sex, ethnicity, trait negative urgency, or day of the week.

Measures

Alcohol use. During morning assessments, participants reported how many drinks they had the night before (0–30+ drinks) on a visual analogue scale. Participants were instructed that one alcoholic drink refers to 12 oz (~350 mL) of 5% beer, 5 oz (~150 mL) of wine, or 1.5 oz (~45 mL) of hard liquor, which is equivalent to roughly 0.6 oz or 14 mL of pure ethanol. Participants were asked at the second assessment whether they completed the morning assessment; if missed, participants completed alcohol use items at that assessment.

Negative affect. At each assessment, participants rated the extent to which they currently felt five negative emotions (*angry*, *anxious*, *bored*, *irritable*, *unhappy*) since (1) the last assessment window or (2) at the morning assessment, since they woke up, on a 100-point visual analogue scale (scale anchors 0 = 'not at all' to 100 = 'very much'). We averaged these five items at each assessment. We averaged the assessments during the morning and midday (Sample 1) and morning, midday, and afternoon (Sample 2) into a daily negative affect score. We did not use the evening and night assessments to calculate daily affect to establish a temporal relationship with subsequent alcohol use. Our negative affect variable showed high reliability across items and time (RkF = 0.96; Shrout and Lane, 2011).

Positive affect. For exploratory analyses, at each assessment, participants rated the extent to which they currently felt five positive emotions (*calm*, *cheerful*, *engaged*, *friendly*, *happy*) since (1) the last assessment window or (2) at the morning assessment, since they woke up, on a 100-point visual analogue scale (scale anchors 0 = 'not at all' to 100 = 'very much'). We averaged these five items at each assessment. We averaged the assessments during the morning and midday (Sample 1) and morning, midday, and afternoon (Sample 2) into a daily positive affect score. Our positive affect variable showed high reliability across items and time (RkF = 0.98).

State urgency. At each assessment, participants were randomly presented four out of six items of the urgency subscales of the UPPS-P (Lynam et al., 2006) on a 100-point visual analogue scale (scale anchors 0 = 'not at all' to 100 = 'very much'). These items were adapted by changing the language from general trait descriptors to past-tense statements that participants rated based on their experience since the last assessment. Furthermore, affect content was removed from the items when appropriate to make the items affect-independent. Items included 'I had trouble controlling my impulses' and 'It was hard for me to resist acting on my feelings' since (1) the last assessment window or (2) since waking up this morning. Because missing data for this scale are by definition MCAR (missing completely at random), computed means are unbiased with respect to the missing data. Thus, we averaged these items at each assessment. Prior work with Sample 1 and an independent sample provided evidence for the multilevel factor structure, reliability, and validity of this measure (Halvorson et al., 2021). We averaged the assessments during the morning and midday (Sample 1) and morning, midday, and afternoon (Sample 2) into a daily urgency score. Our state urgency variable showed high reliability across items and time (RkF = 0.90).

Trait negative urgency. At baseline, participants filled in the 12-item negative urgency subscale from the UPPS Impulsive Behavior scale (Whiteside and Lynam, 2001). Items included 'When I am upset, I often act without thinking' and 'It is hard for me to resist acting on my feelings'. Response options ranged from 1 = 'Disagree Strongly' to 4 = 'Agree Strongly' for all items. We computed a mean score for negative urgency. Internal consistency was high across studies (Cronbach's $\alpha > 0.85$).

Trait positive urgency. For exploratory analyses, we also examined trait positive urgency using 14 items from the UPPS-P Impulsive Behavior scale (Lynam et al., 2006). Items included 'I tend to act without thinking when I am really excited' and 'I am surprised at the things I do while in a great mood'. Response options ranged from 1 = 'Disagree Strongly' to 4 = 'Agree Strongly' for all items. We computed a mean score for positive urgency. Internal consistency was high (Cronbach's $\alpha > 0.85$ for both studies).

Covariates. At baseline, participants reported their biological sex (1 = female, 2 = male) and their ethnicity (0 = non-White, 1 = White). We included biological sex because there are known differences in how males and females physiologically respond to alcohol, and there is some evidence for differences in rates of alcohol use and problems across sex (Foster et al., 2015). We included ethnicity because white young adults in the United States tend to report the highest rates of alcohol use. Because our sample size was limited, our relatively small ($n = 53$) sample of non-White participants precluded a more nuanced treatment of ethnicity. The inclusion of these two variables had the sole purpose of introducing a more competitive baseline comparison for our theoretically motivated variables when it comes to predicting daily alcohol use. We purposefully did not include covariates, which might show strong effects on alcohol use (e.g. time of week), as we would not require our affect-related predictors to outperform such strong effects to have practical significance.

Data analysis

We conducted all analyses in R (version 4.0.3; R Core Team, 2020). To test which model predicting alcohol use has the highest predictive accuracy, we preregistered a Bayesian model comparison procedure (Vehtari and Ojanen, 2012). We derived eight theoretically motivated models predicting alcohol use (described below) and for each of these models calculated model weights based on the leave-one-out (LOO) cross-validation method (Vehtari et al., 2017)[3] to quantify the probability of each model to have the highest predictive accuracy, conditional on the set of models compared (i.e. the cumulative weight of the compared models will always sum to 1). In other words, we tested which combination of predictors best explained nighttime alcohol use, while penalising increasing model complexity (Vehtari et al., 2017). LOO calculates the predictive performance of a model by leaving out observations, one at a time, and testing how well the model fit on the $k-1$ observations does in predicting the left-out observation – if the model has learned something useful from the data, its predictions should generalise from some observations to others. We preregistered to rank the models downwards by their weight and retain and interpret models until their cumulative weight exceeds 90%. Where relevant, we report the 95% Bayesian Credible Interval associated with our effects. A Bayesian Credible Interval can be interpreted intuitively; it indicates that there is a 95% probability that the population parameter value falls within its range.

We fitted the following eight Bayesian mixed-effects models: (1) a covariate-only model including sex and ethnicity as predictors – we used this model instead of an intercept-only model as a more challenging baseline comparison point. In other words, because we expected both sex and ethnicity to be moderate predictors of alcohol use behaviours, we decided that a good model including our focal predictors should out-perform this covariate-only model. Sex and ethnicity were included in all subsequent models as covariates; (2) a model including negative affect as a within-person predictor; (3) a model including trait negative urgency as between-person predictor; (4) a model including state urgency as within-person predictor; (5) a model including negative affect and trait negative urgency as predictors; (6) a model including negative affect and state urgency as predictors; (7) a model including negative affect, trait negative urgency, and their interaction as predictors; (8) a model including negative affect, state urgency, and their interaction as predictors.

We fitted these models using the *brm* function (*brms* package; version 2.14.4; Bürkner, 2017). In our models, the day was the unit of analysis. To model alcohol use, we fitted hurdle models with a negative binomial distribution.[4] Thus, using a mixture model, we simultaneously predicted whether or not any drinking occurred on any given day as well as the number of drinks consumed on drinking days. It is important to note that the hurdle portion of these models predicts the probability of zero, or not reporting alcohol use. We sum-to-zero coded (−1;1) our categorical predictors. We standardised our continuous, within-subjects predictors within participants and then divided by 2 (so $M=0$; SD = 0.5; Gelman et al., 2008). We standardised our continuous, between-subjects predictors on a sample level and then divided by 2. All models included a per-participant random intercept to account for the repeated-measures nature of the data. We modelled no random slopes to keep the complexity of the random effects structure constant across models. This resulted in the general model syntax: brm(bf(alcoholUse ~ 1 + *predictors* + (1| subject), hu ~ 1 + *predictors* + (1| subject), family = hurdle_negbinomial()).

For exploratory purposes, we additionally compared models in which we replaced negative affect and trait negative urgency with positive affect and trait positive urgency, respectively. In all models, we used a preregistered, weakly informative prior (student_t(6, 0, 1.5)) for all fixed effects, which means that our Bayesian models did not make strong prior assumptions about the relevant effects – however, our prior specifies smaller effect sizes (e.g. odds ratios (ORs) between 1 and 2) to be much more likely than larger effect sizes (e.g. ORs larger than 5). For each model, we ran four Markov Chain Monte Carlo (MCMC) chains with 2000 iterations. Following expert recommendations (McElreath, 2020), we inspected model fit using the Rhat statistic, the effective sample size, trace plots to make sure that the chains mixed, and posterior predictive checks.

Results

Descriptive statistics

Participants reported consuming at least one alcoholic drink on 34% of days. On drinking days, participants reported drinking an average of 5.87 drinks. The distribution of number of drinks reported on drinking days is shown in Figure 1(a). Participants were most likely to drink on Thursdays, Fridays, and Saturdays (41.2%) compared to the other days (22.4%). When they drank, they did not report more drinks on Thursdays, Fridays, and Saturdays ($M_{drinks}=5.82$) compared to the other weekdays ($M_{drinks}=6.25$; $BF_{10}=0.11$). Across all days from all participants, both average negative affect ($M=19$, $SD=16$) and state urgency ($M=23$, $SD=19$) were relatively low. Figure 1(b) plots the distribution of negative affect, while Figure 1(c) plots the distribution of state urgency. Negative affect and state urgency were weakly to moderately correlated at the daily level ($r=0.23$); see Figure 1(d) (see also the study by Feil et al., 2020). Participants on average reported medium levels of trait negative urgency ($M=2.37$, SD = 0.58).

Preregistered analyses

Table 1 shows the weights of our preregistered models. This analysis revealed considerable uncertainty regarding the predictive performance of the competing models, with Models 1 to 4 jointly making up 93.5% of the weight. Of note, the model receiving the most weight was the covariate-only model including none of our theoretical predictors. While this model did not clearly outperform the remaining models, this suggested that our predictors of interest had relatively limited predictive value. We display the

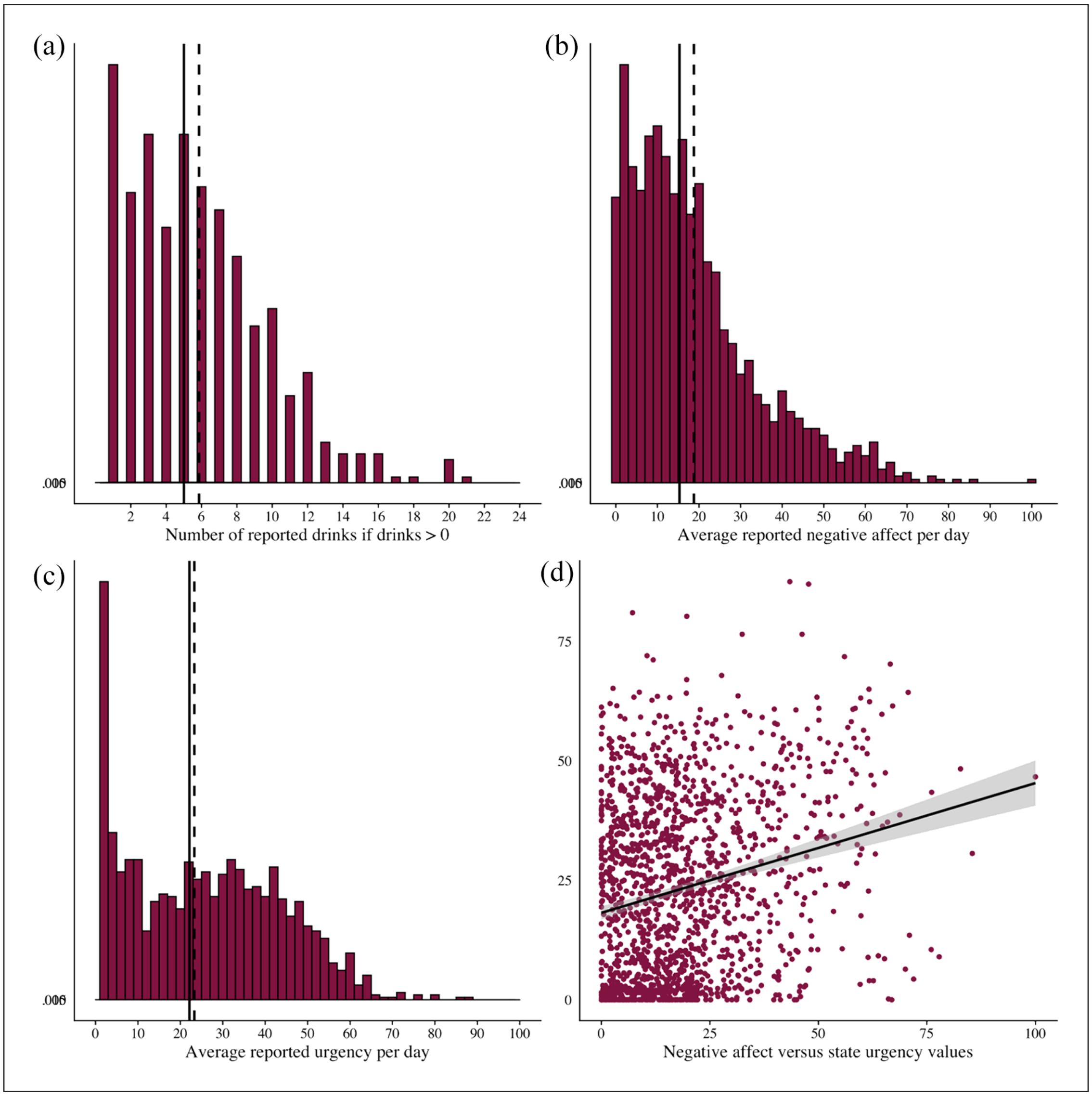

Figure 1. Descriptive statistics. (a)–(c) The solid and dashed lines represent the respective median and mean. (d) The shaded area represents the predicted 95% confidence interval from a linear model.

Table 1. Model weights based on the LOO-statistic of the eight models predicting alcohol use.

Model	Weight
1. Covariate-only	0.342
2. Negative affect	0.149
3. Trait urgency	0.191
4. State urgency	0.253
5. Negative affect + trait urgency	0.001
6. Negative affect + state urgency	0.063
7. Negative affect × trait urgency	0.001
8. Negative affect × state urgency	<0.001

The weight of each model reflects its relative predictive accuracy (contingent on the set of models compared). The weights necessarily sum to 1.

model estimated effects of negative affect (M2), trait negative urgency (M3), and state urgency (M4) in Figure 2.

Results from the baseline model estimated that men were 1.22 times more likely to drink compared to women (95% confidence interval (CI) = (1.02, 1.45)) and were estimated to consume an additional 0.17 drinks on drinking nights (95% CI = (0.06, 0.30)). White students were estimated to be 1.56 times more likely to drink compared to non-White students (95% CI = (1.26, 1.95)) but not to consume more drinks on drinking nights (estimate = 0.03, 95% CI = (−0.08, 0.17)).

As negative affect increased by 8 points (0.5 within-person standard deviations), our model did not estimate participants to be more likely to drink (OR = 0.92, 95% CI = (0.72, 1.20)) nor to consume more drinks (estimate = −0.04, 95% CI = (−0.15, 0.08)). Thus, our posterior distribution indicates a rather narrow range of

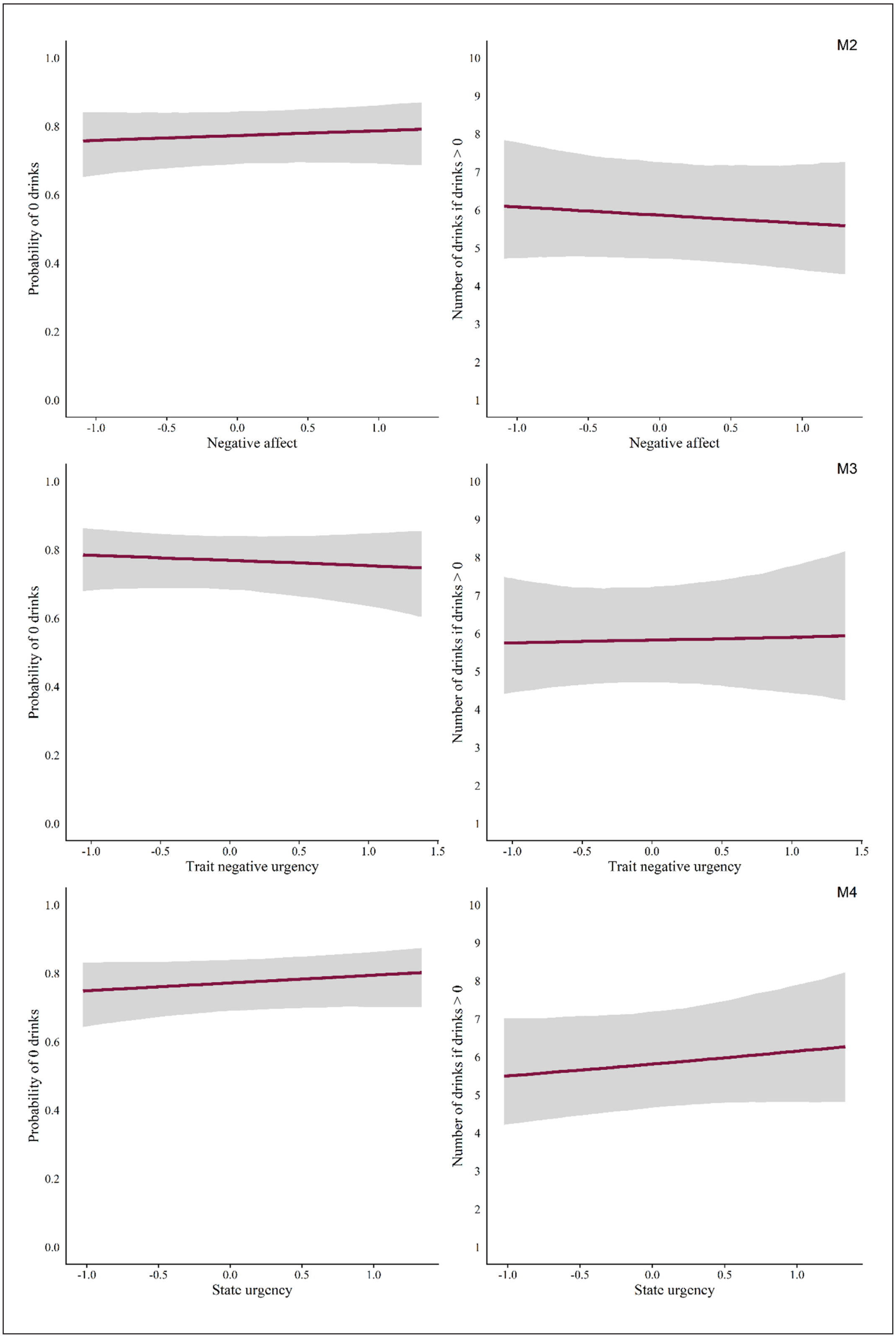

Figure 2. Effects plots of our retained theoretical models. Shown are the effect of negative affect (M2), trait negative urgency (M3), and state urgency (M4) on the probability that no drinking occurred (left) and the number of drinks reported if drinking occurred (right). The shaded areas represent the respective 95% Bayesian Credible Intervals. Increases in our predictors were not associated with meaningful increases in the probability of drinking or the number of alcoholic drinks consumed.

Table 2. Model weights based on the LOO-statistic of the eight enhancement models predicting alcohol use.

Model	Weight
1. Covariate-only	<0.001
2. Positive affect	0.384
3. Trait urgency	0.111
4. State urgency	0.172
5. Positive affect + trait urgency	0.003
6. Positive affect + state urgency	0.101
7. Positive affect × trait urgency	0.229
8. Positive affect × state urgency	<0.001

The weight of each model reflects its relative predictive accuracy (contingent on the set of models compared). The weights necessarily sum to 1.

plausible effect sizes around 0, indicating high certainty regarding the absence of an effect. The estimated main effects for our urgency variables were equally unimpressive ($OR_{trait}=1.08$, 95% CI=(0.76, 1.52); $estimate_{trait}=0.01$, 95% CI=(−0.17, 0.20); $OR_{state}=0.88$, 95% CI=(0.68, 1.13); $estimate_{state}=0.06$, 95% CI=(−0.06, 0.20)).

The effect of negative affect did not change as a function of trait negative urgency; participants were not estimated to be more likely to drink whether they reported high (OR=0.95, 95% CI=(0.71, 1.28)) or low (OR=0.88, 95% CI=(0.65, 1.19)) trait negative urgency as negative affect increased by half a standard deviation. Similarly, participants were not estimated to consume more alcohol on drinking nights whether they reported high (estimate=–0.05, 95% CI=(–0.18, 0.09)) or low (estimate=–0.02, 95% CI=(–0.16, 0.14)) trait negative urgency as negative affect increased by half a standard deviation. The estimated effects for the affect × state urgency interaction were equally unimpressive ($OR_{high}=1.13$, 95% CI (0.84, 1.49); $OR_{low}=0.77$, 95% CI (0.56, 1.06); $estimate_{high}=-0.04$, 95% CI=(−0.21, 0.12); $estimate_{low}=-0.05$, 95% CI=(−0.23, 0.10)).

We conclude from our preregistered analyses that, despite possibly improving our model's accuracy predicting alcohol use beyond sex and ethnicity (as based on the computed model weights), in our data there was no robust evidence for an effect of daily negative affect, or negative urgency at the trait or state level on daily alcohol use. There was even less evidence in our data for the hypothesised negative affect × urgency interaction on the trait and state level. This was true both for the prediction of drinking (vs no drinking) as well as the amount of drinking during drinking nights.

Exploratory analyses

In an exploratory analysis, we repeated our preregistered model comparison, substituting negative affect for positive affect and trait negative urgency for trait positive urgency. The rationale for this analysis is that people might drink to enhance their positive emotions rather than cope with their negative emotions (Cooper et al., 1995). Table 2 shows the weights of our enhancement models. This analysis also revealed considerable uncertainty regarding the ability of the competing models to predict alcohol use, with five of the eight models being assigned a weight of at least 10% (M2, M3, M4, M6, M7). Noteworthy, the covariate-only model did not receive any weight, which implies the general conclusion that the enhancement variables (positive affect and positive urgency) outperform the coping variables (negative affect and negative urgency). The model receiving the most weight was the positive affect model, but it did not convincingly outperform the other four retained models. We have plotted the effects of positive affect (M2) and trait positive urgency (M3) in Figure 3. We have plotted the affect × trait urgency interaction (M7) in Figure 4.

As positive affect increased by 10 points (0.5 within-subjects standard deviations), our model estimated participants to be 1.26 times more likely to drink (95% CI=(0.97, 1.62)) and to consume 0.12 more drinks (95% CI=(−0.01, 0.27)). As trait positive urgency increased by 0.3 points (0.5 between-subjects standard deviations), our model estimated participants to be 1.43 times more likely to drink (95% CI=(1.03, 2.03)) and to consume 0.14 more drinks (95% CI=(−0.04, 0.34)).

The interaction between positive affect and trait positive urgency indicated that for participants higher in positive urgency the association between positive affect and the amount, but not the likelihood, of alcohol use was stronger. For example, participants reporting trait positive urgency half a standard deviation above the sample mean were estimated to be 1.22 times more likely to drink (95% CI=(0.92, 1.62)) and to consume 0.21 more drinks (95% CI=(0.05, 0.38)) during the EMA observation period as positive affect increased by half a standard deviation. In contrast, participants reporting trait positive urgency half a standard deviation below the sample mean were estimated to be 1.30 times more likely to drink (95% CI=(0.95, 1.75)) but to consume equal amounts of drinks (95% CI=(−0.14, 0.17)) as positive affect increased by half a standard deviation.

Our calculated credible intervals indicate that, while there was a consistent positive effect of positive affect and trait positive urgency on subsequent alcohol use in our samples, effect sizes close to zero retain some posterior plausibility. Combined with the model weights, we conclude that there is some evidence in our data for the main effects of positive affect and trait positive urgency on both the likelihood and the amount of drinking during drinking nights. In addition, our data indicate some evidence that the effect of positive affect on the amount of drinking during drinking nights is stronger for participants reporting higher trait positive urgency.

Discussion

Despite decades of theory suggesting that individuals drink to cope with negative affect, daily diary and EMA research have provided mixed evidence at best for a relation between experiences of negative affect and alcohol use. We hypothesised that such mixed findings might be explained by trait or state differences in the tendency to respond impulsively to negative emotions, or negative urgency. Across two EMA samples of moderate-to-heavy drinking college students, our results indicated (1) strong overall evidence against daily associations of negative affect and negative urgency with alcohol use; and (2) some exploratory evidence for daily associations of positive affect and positive urgency with alcohol use. Below, we will discuss these two insights from our research in more detail.

First, our Bayesian modelling results indicated with high certainty that there is no temporal association between negative

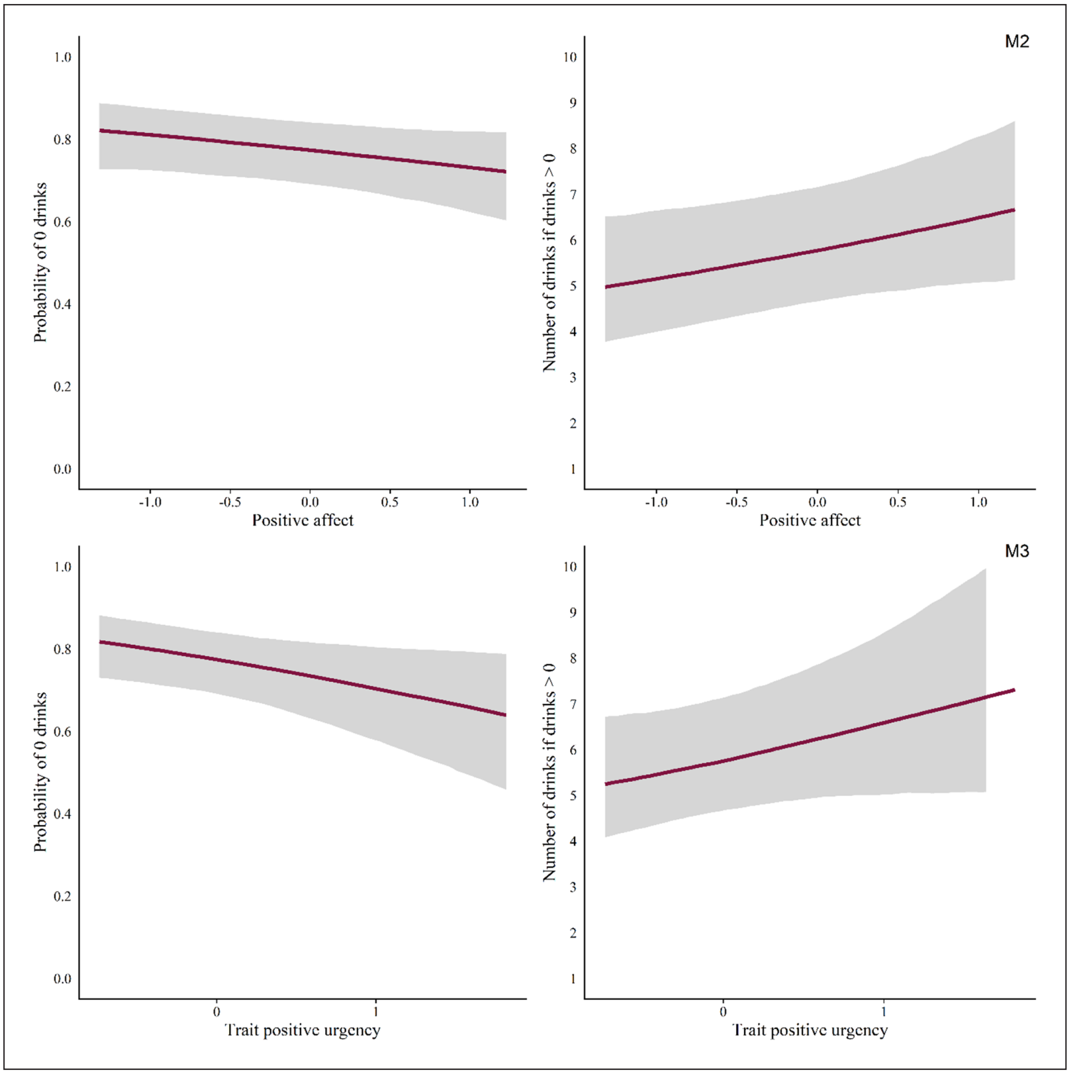

Figure 3. Effects plots of positive affect (M2) and trait positive urgency (M3). Shown are the effect on the probability that no drinking occurred (left) and the number of drinks reported if drinking occurred (right). The shaded areas represent the respective 95% Bayesian Credible Intervals. Increases in positive affect and positive urgency were associated with meaningful increases in the probability of drinking and the number of alcoholic drinks consumed, but these effects were noisy, and effect sizes close to zero retain a small posterior probability based on our analyses.

affect and negative urgency experienced over the course of a day and subsequent alcohol use. Going beyond previous work on this association using exclusively frequentist statistics, our narrow posterior distribution allows us to not only conclude that the effect is not significant, but that indeed meaningful positive effect sizes have tiny posterior probability after conditioning the data on our regularising prior. In other words, not only were there no effects, but there was high certainty that the effect sizes indeed are close to zero. This was true both for negative affect and our urgency variables.

Together with the null associations reported in the majority of recent EMA studies on college student samples (Dvorak et al., 2014, 2018; O'Hara et al., 2014; O'Donnell et al., 2019), we interpret these results as strong evidence against one implication of negative reinforcement and tension reduction models (Baker et al., 2004; Greeley and Oei, 1999) in college students on a daily level. These results may not be generalisable to alternative populations such as clinical samples and older adults (Simons et al., 2017). In addition, the results do not speak to the potential regulating effect of alcohol use on negative affect during the drinking episode. The so-called coping pathway to drinking (responding to negative affect with increased alcohol use) may well be present outside of the population studied here. Similarly, college students may successfully down-regulate their negative affect following alcohol use. That said, the findings from this study suggests that they are not more likely to drink and do not seem to drink more on days characterised by higher negative affect.

Contrary to two previous studies (Bold et al., 2017; Simons et al., 2010), we found no evidence for the hypothesised affect × urgency interaction on alcohol use. However, Bold et al. (2017) tested this interaction in a sample of individuals seeking treatment for their excessive alcohol use, and examined intoxication, rather than use, as a key outcome. It is possible that the effects of

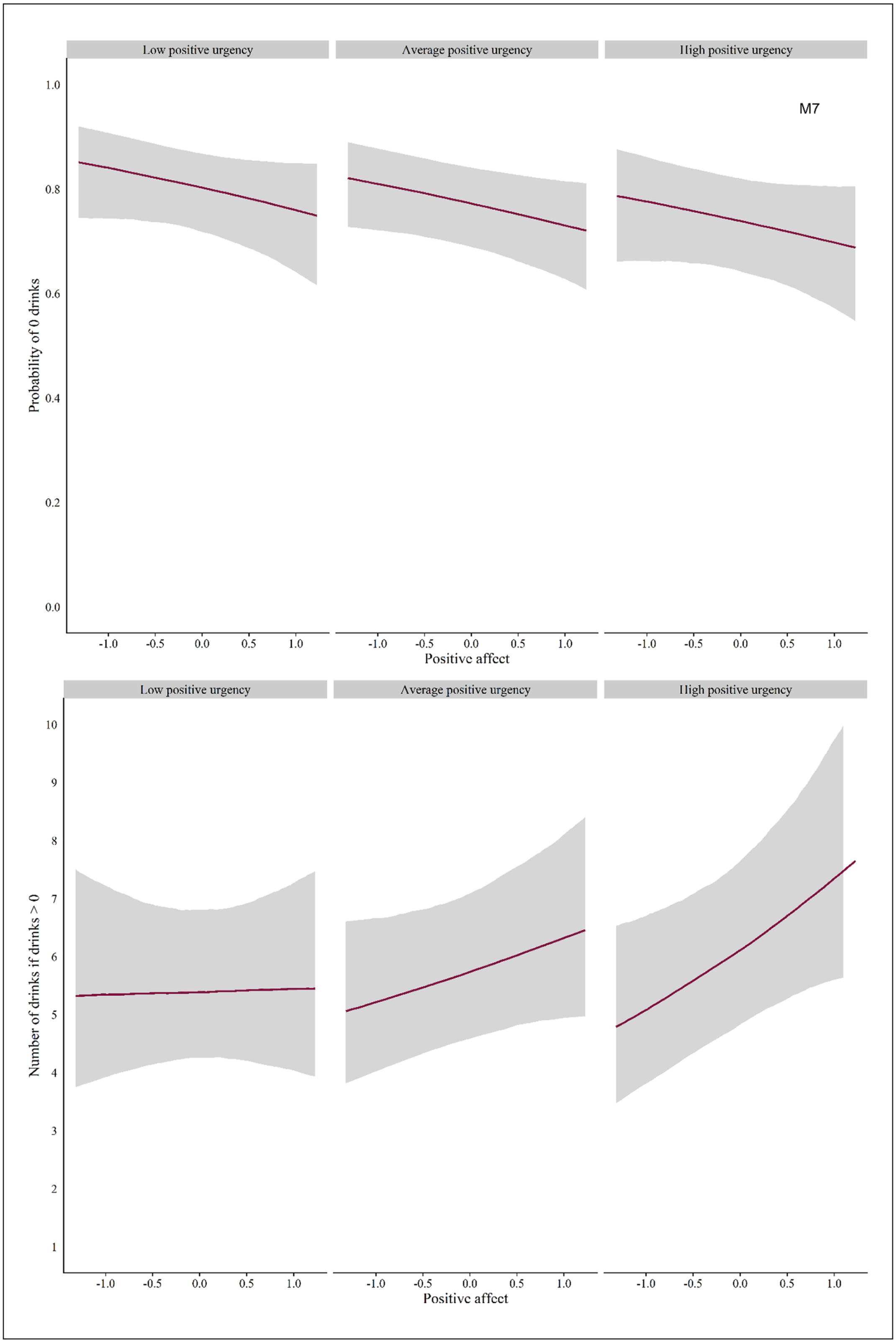

Figure 4. Effects plots of interaction between positive affect and trait positive urgency (M7). Shown are the effect on the probability that no drinking occurred (left) and the number of drinks reported if drinking occurred (right). The shaded areas represent the respective 95% Bayesian Credible Intervals. While participants high (vs low) in positive urgency were no more likely to drink on days high in positive affect, our model estimated them to consume more alcoholic drinks on drinking days high in positive affect.

negative affect on alcohol use differs across college students and clinical samples, which differ by age as well as drinking history. That said, our sample consumed an average of nearly six drinks per occasion, which for most participants would be intoxicating. More research is needed to illuminate the coping pathway (including urgency) in people with an alcohol use disorder. Simons et al. (2010) did find the interaction among college students. It is important to highlight that they tested the hypothesised interaction three times using different 'subscales' of negative affect (sadness, anxiety, and hostility). Of these three interaction tests, only the anxiety × urgency interaction was significant. We could not replicate this finding in this study because we did not assess similar anxiety items. While we cannot rule out the possibility that college students high in negative urgency respond with increased alcohol use to specific negative emotions other than the ones we assessed here, based on our modelling, even these individuals do not drink more on days characterised by high negative affect. This provides further evidence against the negative reinforcement idea in college students beyond the main effect of negative affect; based on our data and modelling results, neither for participants high in urgency nor on days characterised by high urgency should we expect college students to drink more in response to negative affect.

In a non-preregistered exploratory analysis, we showed that variables relating to the enhancement of positive emotions (i.e. positive affect and positive urgency) predicted daily alcohol use much better than the previously discussed coping variables. Although our model comparison procedure was not able to clearly differentiate between several of these enhancement models, collectively they clearly outperformed the covariate-only model, which the negative affect and urgency variables were not able to do. That being said, the effects for positive affect and positive urgency were moderate at best, with effect sizes close to zero retaining some posterior plausibility. Coupled with recent studies using college and young community samples showing mostly positive associations between positive affect and alcohol use on a daily level (for positive findings c.f., Dvorak et al., 2018; Emery and Simons, 2020; Russell et al., 2020; for null findings c.f., O'Donnell et al., 2019; Peacock et al., 2015), we treat our results as moderate evidence for the enhancement hypothesis in college students on a daily level. We did not only find a within-person effect of positive affect on drinking, but also showed that college students higher in positive urgency consume more alcohol and might drink especially more on days characterised by high positive affect. As such, our data and modelling results support a positive (rather than negative) reinforcement cycle in college students. More research is needed to study whether positive reinforcement might lead to alcohol use disorder through habit building the way we think of negative reinforcement of alcohol.

The main limitation of this study lies in the fact that we exclusively sampled young college students. As a result, our results cannot be generalised to the broader population, older adults, or people diagnosed with an alcohol use disorder. We believe we have convincingly shown in this article that young college students, even those high in negative urgency, do not consume more alcohol on days characterised by high negative affect; more research is needed to study this coping pathway to drinking in other populations using preregistered analyses of carefully designed EMA data. Another limitation of our study is the limited negative affect items we assessed. While EMA research necessitates short scales to minimise the burden on the participant, it would be worthwhile for future research to assess a more complete picture of people's affective states to test whether some emotions do a better job predicting alcohol use than others.

In conclusion, this study advanced the EMA literature on affect and alcohol use in at least two ways. First, using a preregistered Bayesian modelling approach, we showed convincingly that negative affect and negative urgency do not meaningfully contribute to our prediction of college students' subsequent drinking behaviour. Second, we showed that positive affect and positive urgency do improve our ability to predict college students' subsequent drinking behaviour on a daily level. Although further research is needed, our results imply the general conclusion that college students drink to enhance rather than drink to cope.

Acknowledgements

We thank Madi Feil, Natalie Upton, Katherine Seldin, and the many undergraduate students who assisted in collecting the data for both samples.

Author contributions

K.M.K. designed the study concept. J.D. analysed the data. J.D., M.E.S., and K.M.K. wrote the article. C.M.L. and Y.S. revised the article. All authors read and approved the final version of the article.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Preparation of this article was supported by a grant from the National Institute on Drug Abuse (DA047247).

ORCID iD

Jonas Dora https://orcid.org/0000-0003-0651-8479

Notes

1. Participants could choose more than one ethnicity, which is why the totals exceed 100%.
2. Thirty-two participants had missing data in at least one variable on every EMA day, which is why the number of participants used in the analyses differs from the number of participants completing the study.
3. We preregistered to calculate the weights based on the Widely Applicable Information Criterion (WAIC). However, using the WAIC to calculate model weights resulted in consistent warnings that the results are unreliable. In line with expert recommendations (Yao et al., 2018), we used the LOO statistic instead.
4. We preregistered to fit hurdle models with a Poisson distribution. However, posterior predictive checks indicated that alcohol use in our samples was much better modelled using a negative binomial model, which is why we chose to deviate from this part of our preregistration.

References

Armeli S, Tennen H, Affleck G, et al. (2000) Does affect mediate the association between daily events and alcohol use? *Journal of Studies on Alcohol* 61(6): 862–871.

Baker T, Piper M, McCarthy D, et al. (2004) Addiction motivation reformulated: An affective processing model of negative reinforcement. *Psychological Review* 111(1): 33–51.

Bold K, Fucito L, DeMartini K, et al. (2017) Urgency traits moderate daily relations between affect and drinking to intoxication among young adults. *Drug and Alcohol Dependence* 170(1): 59–65.

Bürkner P (2017) Brms: An R package for Bayesian multilevel models using Stan. *Journal of Statistical Software* 80(1): 1–28.

Clements R (1999) Prevalence of alcohol-use disorders and alcohol-related problems in a College student sample. *Journal of American College Health* 48(3): 111–118.

Cloninger C (1987) Neurogenetic adaptive mechanisms in alcoholism. *Science* 236(4800): 410–416.

Conger J (1956) Reinforcement theory and the dynamics of alcoholism. *Quarterly Journal of Studies on Alcohol* 17(2): 296–305.

Cooper M, Frone M, Russell M, et al. (1995) Drinking to regulate positive and negative emotions: A motivational model of alcohol use. *Journal of Personality and Social Psychology* 69(5): 990–1005.

Coskunpinar A, Dir A and Cyders M (2013) Multidimensionality in impulsivity and alcohol use: A meta-analysis using the UPPS model of impulsivity. *Alcoholism: Clinical and Experimental Research* 37(9): 1441–1450.

Cyders M and Smith G (2008) Emotion-based disposition to rash action: Positive and negative urgency. *Psychological Bulletin* 134(6): 807–828.

Dvorak R, Pearson M and Day A (2014) Ecological momentary assessment of acute alcohol use disorder symptoms: Associations with mood, motives, and use on planned drinking days. *Experimental Clinical Psychopharmacology* 22(4): 285–297.

Dvorak R, Stevenson B, Kilwein T, et al. (2018) Tension reduction and affect regulation: An examination of mood indices on drinking and non-drinking days among university student drinkers. *Experimental Clinical Psychopharmacology* 26(4): 377–390.

Ehrenberg E, Armeli S, Howland M, et al. (2016) A daily process examination of episode-specific drinking to cope motivation among college students. *Addictive Behaviors* 57(1): 69–75.

Emery N and Simons J (2020) The role of affect, emotion management, and attentional bias in young adult drinking: An experience sampling study. *Psychopharmacology* 237(5): 1557–1575.

Emery R, King K and Levine M (2014) The moderating role of negative urgency on the associations between affect, dietary restraint, and calorie intake: An experimental study. *Personality and Individual Differences* 59(1): 38–43.

Feil M, Halvorson M, Lengua L, et al. (2020) A state model of negative urgency: Do momentary reports of emotional impulsivity reflect global self-report. *Journal of Research in Personality* 86(2): 103942.

Foster K, Hicks B, Iacono W, et al. (2015) Gender differences in the structure of risk for alcohol use disorder in adolescence and young adulthood. *Psychological Medicine* 45(14): 3047–3058.

Gelman A, Jakulin A, Pittau M, et al. (2008) A weakly informative default prior distribution for logistic and other regression models. *Annals of Applied Statistics* 2(4): 1360–1383.

Grant K, Compas B, Stuhlmacher A, et al. (2003) Stressors and child and adolescent psychopathology: Moving from markers to mechanisms of risk. *Psychological Bulletin* 129(3): 447–466.

Greeley J and Oei T (1999) Alcohol and tension reduction. *Psychological Theories of Drinking and Alcoholism* 2(1): 14–53.

Halvorson M, Pedersen S, Feil M, et al. (2021) Impulsive states and impulsive traits: A study of the multilevel structure and validity of a multifaceted measure of impulsive states. *Assessment* 28(1): 1–17.

Hussong A, Hicks R, Levy S, et al. (2001) Specifying the relations between affect and heavy alcohol use among young adults. *Journal of Abnormal Psychology* 110(3): 449–461.

Hussong A, Jones D, Stein G, et al. (2011) An internalizing pathway to alcohol use and disorder. *Psychology of Addictive Behaviors* 25(3): 390–404.

Khantzian E (1990) Self-regulation and self-medication factors in alcoholism and the addictions. Similarities and differences. *Recent Developments in Alcoholism* 8: 255–271.

King K, Feil M and Halvorson M (2018) Negative urgency is correlated with the use of reflexive and disengagement emotion regulation strategies. *Clinical Psychological Science* 6(6): 822–834.

Kotov R, Gamez W, Schmidt F, et al. (2010) Linking "big" personality traits to anxiety, depressive, and substance use disorders: A meta-analysis. *Psychological Bulletin* 136(5): 768–821.

Lynam D, Smith G, Whiteside S, et al. (2006) The UPPS-P: Assessing five personality pathways to impulsive behavior. Technical Report, Purdue University, West Lafayette, IN.

McElreath R (2020) *Statistical Rethinking: A Bayesian Course with Examples in R and Stan*. Boca Raton, FL: Chapman & Hall.

Malouff J, Thorsteinsson E, Rooke S, et al. (2007) Alcohol involvement and the five-factor model of personality: A meta-analysis. *Journal of Drug Education* 37(3): 277–294.

Mohr C, Brannan D, Mohr J, et al. (2008) Evidence for positive mood buffering among college student drinkers. *Personality and Social Psychology Bulletin* 34(9): 1249–1259.

Mohr C, Brannan D, Wendt S, et al. (2013) Daily mood- drinking slopes as predictors: A new take on drinking motives and related outcomes. *Psychology of Addictive Behaviors* 27(4): 944–955.

O'Donnell R, Richardson B, Fuller-Tyskiewicz M, et al. (2019) Ecological momentary assessment of drinking in young adults: An investigation into social context, affect, and motives. *Addictive Behaviors* 98: 106019.

O'Hara R, Armeli S and Tennen H (2014) Drinking-to-cope motivation and negative mood-drinking contingencies in a daily diary study of college students. *Journal of Studies on Alcohol and Drugs* 75(4): 606–614.

Owens M, Amlung M, Stojek M, et al. (2018) Negative urgency moderates reactivity to laboratory stress inductions. *Journal of Abnormal Psychology* 127(4): 385–393.

Park C, Armeli S and Tennen H (2004) The daily stress and coping process and alcohol use among college students. *Journal of Studies on Alcohol* 65(1): 126–135.

Peacock A, Cash C, Bruno R, et al. (2015) Day-by-day variation in affect, arousal and alcohol consumption in young adults. *Drug and Alcohol Review* 34(6): 588–594.

R Core Team (2020) *R: A Language and Environment for Statistical Computing*. Vienna: R Foundation for Statistical Computing. Available at: https://www.r-project.org

Rankin L and Maggs J (2006) First-year college student affect and alcohol use: Paradoxical within- and between-person associations. *Journal of Youth and Adolescence* 35(6): 925–937.

Riley E, Combs J, Jordan C, et al. (2015) Negative urgency and lack of perseverance: Identification of differential pathways of onset and maintenance risk in the longitudinal prediction of nonsuicidal self-injury. *Behavior Therapy* 46(4): 439–448.

Russell M, Linden-Carmichael A, Lanza S, et al. (2020) Affect relative to day-level drinking initiation: Analyzing ecological momentary assessment data with multilevel spline modeling. *Psychology of Addictive Behaviors* 34(3): 434–446.

Settles R, Zapolski T and Smith G (2014) Longitudinal test of a developmental model of the transition to early drinking. *Journal of Abnormal Psychology* 123(1): 141–151.

Shrout P and Lane S (2011) Psychometrics. In: Mehl M and Connor T (eds) *Handbook of Research Methods for Studying Daily Life*. New York: Guildford Press, pp. 302–320.

Simons D, Shoda Y and Lindsay S (2017) Constraints on Generality (COG): A proposed addition to all empirical papers. *Perspectives on Psychological Science* 12(6): 1123–1128.

Simons J, Dvorak R, Batien B, et al. (2010) Event-level associations between affect, alcohol intoxication, and acute dependence symptoms: Effects of urgency, self-control, and drinking experience. *Addictive Behaviors* 35(12): 1045–1053.

Simons J, Gaher R, Oliver M, et al. (2005) An experience sampling study of associations between affect and alcohol use and problems among college students. *Journal of Studies on Alcohol* 66(4): 459–469.

Stevenson B, Dvorak R, Kramer M, et al. (2019) Within- and between-person associations from mood to alcohol consequences: The mediating role of enhancement and coping drinking motives. *Journal of Abnormal Psychology* 128(8): 813–822.

Vehtari A and Ojanen J (2012) A survey of Bayesian predictive methods for model assessment, selection and comparison. *Statistics Surveys* 6: 142–228.

Vehtari A, Gelman A and Gabry J (2017) Practical Bayesian model evaluation using leave- one-out cross-validation and WAIC. *Statistics and Computing* 27(5): 1413–1432.

Waddell J, Sher K and Piasecki T (2021) Coping motives and negative affect: An ecological study of the antecedents of alcohol craving and alcohol use. *Psychology of Addictive Behaviors* 35(5): 565–576.

Whiteside S and Lynam D (2001) The Five Factor Model and impulsivity: Using a structural model of personality to understand impulsivity. *Personality and Individual Differences* 30(4): 669–689.

Wills T and Filer M (1996) Stress–coping model of adolescent substance use. In: Ollendick T and Prinz R (eds) *Advances in Clinical Child Psychology*. New York: Plenum, pp. 91–132.

Yao Y, Vehtari A, Simpson D, et al. (2018) Using stacking to average Bayesian predictive distributions (with discussion). *Bayesian Analysis* 13(3): 917–1007.