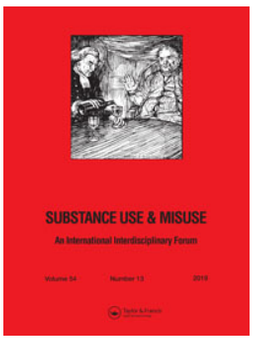

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ORIGINAL ARTICLE

Risk-Taking Propensity, Affect, and Alcohol Craving in Adolescents' Daily Lives

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ABSTRACT

Background: Alcohol craving is common among adolescents, stronger among those with more alcohol-related problems, and predicts drinking levels in their daily lives. Yet, the conditions that predict momentary changes in craving in real time among adolescents remain unclear. *Objectives:* This study examined the interactive effects of momentary risk-taking propensity and affect on adolescents' alcohol craving by leveraging ecological momentary assessment (EMA) methods. *Methods:* Participants were 29 adolescents ages 15–19 years (55% female; 69% White; 10% Black; 17% Hispanic); 45% met criteria for alcohol dependence. Following a laboratory session that captured self-report and behavioral assessments, including the well-established Balloon Analog Risk Task (BART), participants completed multiple daily assessments of alcohol craving, positive and negative affect, and risk propensity for approximately one week. Momentary risk propensity was captured in real-world settings via an EMA behavioral task ("Balloon Game"). *Results:* Mixed-effects models with EMA reports (Level 1) nested within participants (Level 2) revealed the majority (74%) of variability in "Balloon Game" performance was due to within-person, momentary, fluctuations. Greater momentary positive affect predicted increased alcohol craving, but only when participants exhibited heightened risk-taking propensity. Negative affect did not influence the relation between momentary risk-taking and craving. *Conclusions/Importance:* Momentary fluctuations in positive affect predicted acute increases in craving but only in moments when adolescents demonstrated higher levels of risk-taking propensity, as captured with an EMA-delivered behavioral task. Momentary risk-taking assessments offer new avenues to substantiate dominant theories on the driving mechanisms of craving and alcohol use among adolescents.

KEYWORDS
Ecological momentary assessment; affect; risk-taking; adolescents; craving

Alcohol use and related problems, including the onset of alcohol use disorder (AUD), peak during adolescence and early adulthood (Johnston et al., 2018). Yet important aspects of how drinking problems develop and progress during this key developmental phase remain poorly understood. Alcohol craving, defined as the subjective state of wanting or desire to drink (Kozlowski et al., 1989), emerges early in an individual's drinking history (O'Loughlin et al., 2003; Tiffany, 2010). Cross-sectional research indicates craving is common among adolescents (Deas et al., 2001, 2005; Martin et al., 1995), stronger among teenagers with more alcohol-related problems (Curtin et al., 2005; Tapert et al., 2003; Thomas et al., 2005), and predicts drinking levels in adolescents' daily lives (Miranda, Monti et al., 2014). What remains unclear, however, are the conditions that predict acute changes in adolescent alcohol craving.

Adolescence is marked by rapid spikes in mood-driven and risk-prone behavior (Buchanan et al., 1992; Somerville et al., 2010; Steinberg, 2011). Indeed, teenagers often experience intense and volatile emotions (Arnett, 1999; Larson et al., 2002), and this affective liability drives strong approach tendencies toward rewards while discounting potential negative consequences (Somerville et al., 2010; Steinberg, 2008). This confluence of heightened emotionality and risk-taking propensity is implicated in the escalation of adolescent alcohol use and may be important for understanding fluctuations in craving. However, no study has characterized the interplay among momentary affect, risk-taking propensity, and alcohol craving in adolescents. This is a considerable shortfall, particularly as converging evidence across empirical reviews, meta-analyses, clinical trials, and laboratory studies support craving as a key motivational determinant of

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alcohol use and relapse (Addolorato et al., 2005; Bottlender & Soyka, 2004; Carter & Tiffany, 1999; Field & Cox, 2008; Field et al., 2013; Flannery et al., 2003; Gordon et al., 2006; Ramirez & Miranda, 2014). The present study leveraged ecological momentary assessment (EMA) methods to provide initial data on the extent to which acute changes in mood and risk-taking propensity interact to predict acute increases in craving among adolescents in the natural environment.

Affect is a prominent component of conceptual models of craving and addiction more broadly (Baker et al., 2004; Koob & Le Moal, 2001; Volkow et al., 2016). Empirical support for the association between affective states and craving stems from clinical and human laboratory studies with adults (Bresin et al., 2018; Mason et al., 2008; Petit et al., 2017), and growing evidence indicates that affect-related craving predicts alcohol use and problems among young adults (Soltis et al., 2017; Tripp et al., 2015) as well as treatment effects in clinical trials (Witkiewitz & Bowen, 2010). Although teenagers commonly endorse affect as a key motivator for alcohol involvement and studies show that affect often drives adolescent drinking (Cooper et al., 2015; Kuntsche & Müller, 2012; Kuntsche et al., 2006), no study to our knowledge examined associations between affect and alcohol craving among adolescents. This leaves important unanswered questions about whether and how research with adults applies to adolescents. Moreover, although prior research implicates the importance of emotional states in craving and use in adults, it does not inform whether moment-to-moment variations in affect are associated with momentary acute changes in craving.

Mounting evidence also supports a link between risk propensity and alcohol craving. Risk propensity may be assessed in the human laboratory using behavioral tasks, such as the Balloon Analog Risk Task (BART: Lejuez et al., 2002), which is a sequential decision-making paradigm that requires respondents to choose between risky and safe options to earn rewards. Human laboratory studies with adults show that higher risk propensity, as measured using the BART, is associated with stronger alcohol obsessions and cravings (Clay et al., 2018; Heinz et al., 2016) and similar effects are found among problem gamblers (Miedl et al., 2014). In addition, research shows the association between risk propensity and alcohol craving may help explain individual variability in stress-induced craving, such that those with greater risk propensity experience greater craving when faced with psychosocial stressors (Clay et al., 2018). But whether associations between affect, risk propensity, and craving generalize to real-world settings and vary moment-to-moment, within-persons, remains untested. The potential mismatch between traditional laboratory-based measurement approaches and lived experiences triggered newer research seeking to characterize risk-taking propensity as a time-varying construct sensitive to a variety of contextual influences (MacLean et al., 2018). Here, research supports the feasibility of capturing momentary changes in risk-taking propensity on mobile devices in real-world settings and speaks to the potential benefit of assessing variability in risk-taking propensity at the within-person level, rather than entirely at the between-person level. In addition, despite the heightened salience of risk propensity during adolescence – the developmental period when risk-taking peaks and brain circuitry that governs regulation of impulse control and motivation for rewards undergoes major neuromaturation – no study has examined the association between risk propensity and alcohol craving in this age group. Although research shows that adolescents who engage in excessive substance use exhibit greater risk propensity on laboratory tasks (Aklin et al., 2005; Fernie et al., 2010; Lejuez et al., 2005; Williams et al., 2010), whether risk propensity fluctuates moment-to-moment and predicts momentary changes craving among adolescents remains unknown.

The current study combines laboratory and EMA methods to test associations among risk-taking propensity, affect, and craving in adolescents' (ages 15–19 years) daily lives. Consistent with recent work (MacLean et al., 2018), We expected *in vivo* assessments of adolescent risk-taking propensity to show substantial within-person variation that is not explained by laboratory assessments. In addition, we expected both laboratory-based and momentary risk-taking propensity assessments to predict increased alcohol craving in adolescents' daily lives. Finally, building on initial laboratory findings (Clay et al., 2018), we purport that risk-taking propensity plays an influential role in an individual's momentary affect and its association with alcohol craving. Specifically, we predicted that risk-taking propensity would moderate momentary associations between affect and craving, such that affect would more strongly relate to alcohol craving during instances of heightened risk-taking propensity. Understanding these associations is especially important during adolescence, a developmental period marked by elevated emotion-driven rash action.

Method

Participant selection

Participants were 15- to 19-year-old male and female adolescents recruited from schools and the community. Community-based recruitment approaches included posting flyers in areas frequented by adolescents (e.g., recreation centers, parks), distributing study brochures where adolescents gather (e.g., malls, athletic events), and posting advertisements in local and regional newspapers. The present study utilized data from a 1-week, baseline period preceding a randomized clinical trial that evaluated the effects of naltrexone on teenagers' reactions to alcohol (Miranda, Ray et al., 2014). Participants were randomized to medication groups after the conclusion of this baseline period. To be eligible for the larger trial, adolescents were required to consume alcohol at least twice weekly in the past 30 days, be able to read simple English, and be postpubescent. Adolescents with a history of alcohol treatment or currently seeking formal treatment for alcohol were ineligible. Other reasons for ineligibility included opiate use in the past 30 days; current or past opiate use disorder based on the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-IV-TR; Association, 2000); positive urine toxicology screen for opiates or narcotics, amphetamines, or sedative hypnotics; clinically significant alcohol withdrawal; suicidal or psychotic; and medical conditions or medications that contraindicated taking the study medication (i.e., naltrexone) in the larger clinical trial.

Procedures

The University Institutional Review Board approved the study. Interested adolescents completed an initial telephone screening, and potentially eligible adolescents completed an in-person screening. Study procedures were fully described to all participants and parents for participants younger than 18 years. Participants ages 18 or 19 years and parents of minors provided consent; minors provided assent.

Participants completed several laboratory tasks including alcohol cue reactivity, picture cue reactivity, and a risk-taking assessment. The cue reactivity tasks, which are described elsewhere (Miranda, Ray et al., 2014), were not part of the present analysis. Participants then received detailed instruction in our EMA protocol, which we designed for this research and implemented on Samsung smartphones provided by the study. Training incorporated an age-appropriate graphic manual outlining the EMA risk-taking assessments and all other EMA response types and options. The present analyses focus on device-initiated audible prompts assessing craving and momentary risk-taking, administered randomly in 3-hour time blocks (referred to herein as "random prompts"). To ensure true "in-the-moment" responses, reports not completed within 2 minutes were marked as missed. Only reports completed prior to alcohol use on any day were included in the present study to avoid conflating pre-drinking craving levels with craving influenced by the pharmacological effects of alcohol.

Laboratory measures

Demographics, alcohol use, and alcohol-related problems

Laboratory assessments included participant demography, a 90-day timeline follow-back interview (Sobell et al., 1988), and the Rutgers Alcohol Problem Index (RAPI; White & Labouvie, 1989). In addition, alcohol use disorders were derived using the Kiddie Schedule for Affective Disorders for School-Age Children (Kaufman et al., 1997). Diagnostic decisions were based on adolescents' reports, made by case consensus. Two licensed psychologists participated in all case consensus reviews. These measures were used to describe our sample and calculate covariates, including percent drinking days, percent heavy drinking days, and alcohol-related problems (i.e., RAPI total score).

BART

Risk-taking propensity was assessed in the laboratory with the traditional BART (Lejuez et al., 2002). This sequential decision-making paradigm, which is thought to provide an estimate of respondents' real-world risk-taking propensity, requires respondents to choose between risky- and safe-play options on 30 consecutive trials. When respondents select the risky-play option (i.e., by pressing the inflate button), a virtual balloon 'inflates' on the computer screen. If the balloon expands without exploding the respondent wins a hypothetical reward. If the balloon over-inflates and explodes, however, the respondent forfeits their hypothetical winnings. Alternatively, the safe-play option affords respondents the opportunity to stop playing at any trial and collect their hypothetical reward. The object of the task is to win as many rewards as possible. Balloons varied in their explosion points. No monetary or other type of reward or prize was provided at the end of the task. Prior studies show hypothetical rewards yield valid data in both

between- and within-persons comparisons (Madden et al., 2003, 2004). We used adjusted BART scores, i.e., average number of "pump" options taken on non-exploded balloons as a behavioral index of risk-taking (Pleskac et al., 2008).

EMA (momentary) measures

Alcohol craving

Urge to drink was assessed using a single-item visual analog scale with endpoints labeled 0 (no urge) to 10 (strongest ever). This assessment is routinely used in our EMA studies with adolescents and adults and relates to AUD and drinking outcomes (Miranda, Monti et al., 2014; Miranda et al., 2018, Treloar Padovano, & Miranda, 2018).

Positive and negative affect

Participants rated how excited, energized, stressed, and tense they felt "right now" using a visual analog scale with endpoints labeled 0 (not at all) to 10 (extremely). The average of stressed and tense captured negative affect, $\alpha = .74$, and the average of energized and excited captured positive affect, $\alpha = .87$.

Contextual covariates

Additional contextual covariates were assessed concurrently in-the-moment with craving and affect. Participants recorded whether peers were present and whether they were in a location where they would typically consume alcohol. Device timestamps allowed for coding of hour of day and weekend status (weekend defined as Saturday or Sunday). Timestamps also allowed for a sequential count of EMA reports. Prior research with a similar mobile balloon task suggests participants' adjusted average number of pumps increased with repeated administrations of the momentary measure (MacLean et al., 2018); this sequential count variable accounted for such potential effects.

Balloon game

Momentary risk-taking was assessed with a single-trial task described to participants as the "Balloon Game." Participants were instructed: "When you play the Balloon Game, I'll ask you the number of times you would like to pump up a balloon, from 0 to 128. Each pump adds air to the balloon. The bigger you pump the balloon the more pretend money you could win. However, if the balloon explodes, you won't win any pretend money."

Participants entered a 3-digit number directly on the handheld device and could choose to clear the number if they made a mistake or tap "OK" to proceed. They then watched the virtual balloon automatically 'inflate' until either the entered number of pumps was reached or it exploded. The number of 'pumps' participants entered for each trial was used in analyses.

Data analytic strategy

Mixed-effect models (i.e., multilevel models; Raudenbush & Bryk, 2002) accounted for (a) the nesting of momentary reports (Level 1) within participants (Level 2), (b) varying numbers of momentary reports per participant, and (c) individual variability in EMA momentary risk-taking. Modeling was implemented with SAS 9.4 software (SAS Institute, Inc., Cary, NC). All continuous predictors were standardized and binary predictors were effect coded to facilitate comparison/scaling of effect estimates. Level 1 standardization of continuous predictors was implemented within persons.

An initial, intercept-only model explored variability in EMA risk-taking through estimating variance at Levels 1 and 2, used to calculate the intraclass correlation coefficient (ICC), i.e., the ratio of variance between persons (Level 2) to total variance (Singer & Willet, 2003). The ICC was used to calculate the percent variance in EMA risk-taking accounted for by Level 1 (momentary; within-person) and Level 2 (individual difference; between-person) factors. Next, the intercept-only model was compared to a model including the laboratory BART as a sole predictor to evaluate the extent to which EMA risk-taking propensity ('Balloon Game') was explained by the laboratory-based BART assessment.

A second aim was to predict a substantive outcome from our EMA measure of in-the-moment risk-taking. We hypothesized that positive/negative affect and EMA risk-taking would interact to predict adolescents' concurrent alcohol craving. Due to the positive skew of craving, the likelihood of experiencing alcohol craving (0 = no urge; 1 = any urge value > 0) and craving strength were estimated with PROC GLIMMIX with binary and negative binomial distributions, respectively. Initial models identified significant predictors of craving to be included as covariates in additional models. Level 1 (momentary) and Level 2 (individual difference) influences of affect were distinguished through a contextual model including the momentary assessment of the affective state (Level 1 effect) along with the average of all momentary assessments of that affective state over the course of the study for each person individually (i.e., the person average; Level 2 effect). Interactive effects of EMA risk-taking and momentary affect tested whether craving was

influenced by the dynamic interplay of momentary risk-taking propensity and concurrent positive or negative affective experience.

Results

Participant characteristics

Twenty-nine adolescents met eligibility criteria and provided data during the baseline period. Approximately, half of the sample was female (55.2%); the majority was White (71.4%), but adolescents identifying as Black or African American (10.7%) or Asian (10.7%) were oversampled relative to the surrounding community. Additionally, one participant identified as American Indian or Alaskan Native (3.6%) and another as Pacific Islander (3.6%). One participant did not report their race and identified as Hispanic (3.6%). Overall, 17.2% indicated Hispanic ethnicity. On average, participants reported drinking on 28.0% of the past 90 days (SD = 16.7), and of drinking days, 49.8% were heavy drinking days (females $\geq$ 4, males $\geq$ 5; SD = 28.5). On average, participants reported 4.8 standard drinks per drinking day (SD = 3.3, range = 2 to 20) in the past 90 days. Eight participants (27.6%) met criteria for current DSM-IV-TR alcohol abuse; 13 (44.8%) met criteria for current alcohol dependence.

Momentary risk-taking propensity

The intercept from an unconditional means model (i.e., without any predictors; also referred to as "intercept-only" model) was 56.94 (SE = 2.99), indicating that, on average, participants entered approximately 57 "pumps" in the EMA risk-taking propensity task. The ICCs were calculated from the ratio of between and total variance of this unconditional model. The ICC was .26, indicating that 26% of the variability in momentary risk-taking propensity was accounted for by between- (person) level factors. Put differently, momentary influences explained nearly three-quarters (74%) of the variability in risk-taking propensity task performance. The ICC also estimates the residual autocorrelation of EMA risk-taking propensity assessments, suggesting the average correlation between any pair of assessments *in vivo* was $r = .26$. To evaluate the extent to which EMA (momentary) risk-taking propensity was explained by the traditional laboratory-based assessment, the next model included the fixed effect of the laboratory BART as a sole predictor of the EMA task. The fixed effect of laboratory BART on momentary risk-taking propensity was not significant, 95% CI (−5.54, 7.49), $p = .760$, suggesting that variability in the EMA assessment was not sufficiently accounted for by individual differences in risk-taking propensity measured in the laboratory.

Momentary and laboratory-based risk-taking influences on craving

First, we validated that craving was a meaningful predictor of drinking in our sample by comparing craving on drinking and non-drinking days. A one-unit increase in craving (0–10 scale) was associated with 1.21 times the odds of drinking on a given day, OR = 1.21, [95% CI = 1.08, 1.35], $b = 0.19$, SE = 0.06, $p = .001$. Next, we tested whether positive and negative affective states were also predictors of drinking. A one-unit increase in momentary positive affect (0–10 scale) was associated with 1.78 times the odds of drinking on a given day, OR = 1.78, [95% CI = 1.26, 2.51], $b = 0.58$, SE = 0.17, $p = .001$. Person-average positive affect was not related to drinking, $p = .433$, and neither were momentary or person-average negative affect, ps = .276 and .122, respectively.

Of several covariates tested (Level 1: hour of day, sequential count of EMA reports, presence of peers, weekend, location where typically drink; Level 2: sex, age, percent drinking days, percent heavy drinking days, RAPI score), only peer presence was a significant influence on likelihood of experiencing craving, and thus was the only covariate retained in subsequent models. Odds of experiencing craving when in the presence of peers was 4.21 times that when peers were not present, $p = .001$. In a model accounting for the presence of peers, our hypotheses regarding the main effects of laboratory and EMA risk-taking on craving likelihood in the natural environment were not supported, ps = .185 and .656, respectively. The same result was found for craving strength (0–10), modeled with a negative binomial distribution, ps = .369 and .214, respectively.

Interactive influences of affect and risk-taking propensity on craving

In a model accounting for presence of peers and disaggregating within- and between-level influences of affect (Table 1), heightened momentary positive affect was linked to greater craving strength (RR = 1.41, $p = .040$) but not likelihood (OR = 1.22, $p = .256$). This relation was moderated by momentary risk-taking (craving likelihood: OR = 1.41, $p = .057$, marginal; craving strength: RR = 1.41, $p = .003$). In contrast, momentary negative affect was not related to

Table 1. Multilevel models predicting craving from the interactive effects of affective states with momentary and laboratory-based risk-taking assessments.

	Likelihood of craving				Strength of craving			
	OR	*b*	SE	*p*	RR	*b*	SE	*p*
Positive affect (i.e., Energized/Excited)								
Intercept	0.61	−0.50	0.38	.206	0.84	−0.17	0.28	.549
Presence of peers	3.58	1.27	0.41	.005	2.53	0.93	0.26	.002
Momentary risk-taking	1.22	0.20	0.19	.311	1.27	0.24	0.12	.053
Laboratory risk-taking	1.52	0.42	0.35	.237	1.20	0.18	0.24	.453
Momentary positive affect	1.24	0.22	0.19	.244	1.37	0.32	0.12	.010
Person-average positive affect	0.95	−0.05	0.33	.879	1.08	0.08	0.23	.722
Momentary risk-taking × Momentary positive affect	1.41	0.35	0.18	.057	1.41	0.34	0.11	.003
Laboratory risk-taking × Momentary positive affect	1.23	0.20	0.17	.243	1.22	0.20	0.11	.081
Negative affect (i.e., Stressed/Tense)								
Intercept	0.58	−0.54	0.34	.121	0.84	−0.17	0.26	.521
Presence of peers	3.43	1.23	0.38	.004	2.84	1.04	0.25	< .001
Momentary risk-taking	1.14	0.13	0.18	.473	1.19	0.18	0.12	.159
Laboratory risk-taking	1.54	0.43	0.29	.146	1.25	0.22	0.21	.310
Momentary negative affect	0.81	−0.21	0.18	.253	1.01	0.01	0.11	.961
Person-average negative affect	1.98	0.68	0.28	.025	1.41	0.34	0.20	.103
Momentary risk-taking × Momentary negative affect	0.85	−0.16	0.17	.367	0.91	−0.10	0.11	.394
Laboratory risk-taking × Momentary negative affect	1.19	0.18	0.18	.335	1.09	0.09	0.11	.443

Note. OR: odds ratio; b: unstandardized estimate; SE: standard error. Likelihood of craving is modeled with a binary distribution, and strength of craving is modeled with a negative binomial distribution. Presence of peers is effect coded (−1 = no peers present; 1 = peers present). All predictors were standardized prior to model entry (momentary affective states were standardized within persons). The same pattern of results is maintained when interactive effects are tested separately for momentary and laboratory risk-taking.

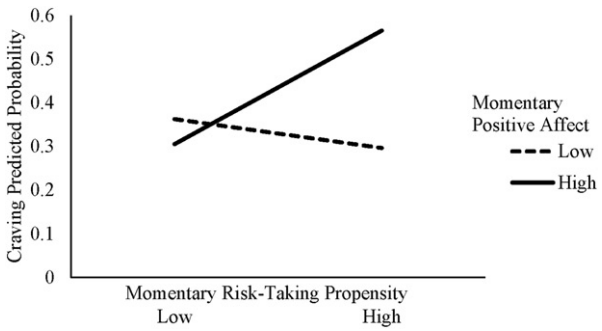

Figure 1. Predicted probability of craving at high (+1 SD) and low (−1 SD) levels of momentary positive affect and EMA Balloon Game performance.

craving likelihood or strength, *p*s = .328 and .767, respectively, and momentary risk-taking did not moderate this relation (craving likelihood: $p = .367$; craving strength: $p = .394$). Effects for moderation of positive-affect craving relations remained significant when all potential momentary and person covariates were included (i.e., sequential count of EMA reports, presence of peers, weekend, location where typically drink, sex, age, percent drinking days, percent heavy drinking days, RAPI score) (craving likelihood: OR = 1.55, $p = .028$; craving strength: RR = 1.40, $p = .004$). In a model excluding all covariates, the moderating effect of momentary risk-taking was significant for craving strength, RR = 1.34, $p = .012$, but not likelihood, $p = .114$.

The moderating effect of momentary risk-taking on the link of positive affect and craving strength is illustrated in Figure 1 by plotting model-based (empirical Bayes) predicted probability of craving at ±1 SD of EMA Balloon Game number of "pumps" and momentary positive affect. When positive affect is low, EMA (momentary) risk-taking propensity has little influence on the probability of experiencing craving, with the predicted probability ranging from 29.6% to 36.2% at high and low levels of risk-taking, respectively. In contrast, at times when positive affect is heightened, the probability of experiencing craving increases from 30.5% if in-the-moment risk-taking propensity is low, to 56.5% if in-the-moment risk-taking is high.

Discussion

This study leveraged EMA methods to examine the interplay among positive and negative affect, risk propensity, and alcohol craving among adolescent problem drinkers in real-time in their daily lives. The main findings show that momentary fluctuations in positive affect predict acute increases in craving but only in moments when adolescents demonstrated higher levels of risk-taking propensity, as captured with a novel EMA-delivered behavioral task. These effects remained significant even while controlling for a variety contextual factors, namely time of day, the presence of peers, whether it was a weekend, and whether adolescents were in a location where they typically drink. Momentary changes in negative affect were not associated with fluctuations in alcohol craving or risk propensity.

Theoretical models identify craving as a complex construct reflecting a motivational drive to relieve negative emotions, enhance positive emotions, or both (Baker et al., 2004; Koob & Le Moal, 2001; Verheul et al., 1999). Our finding that momentary affect predicts craving but only in when adolescents exhibit heightened levels of risk propensity coincides with recent research that suggests underlying risk-taking tendencies may moderate associations between stress and alcohol craving among young adult social drinkers (Clay et al., 2018). Importantly, this work by Clay et al. (2018) is the only other study to our knowledge to examine these associations. Although both studies implicate the importance of affect and risk propensity for understanding alcohol craving, we found an effect for positive-affect-induced craving, but not negative-affect-induced craving. Clay et al. (2018) only measured risk propensity in the laboratory using the traditional BART and they did not assess the impact of positive affect. It is possible that associations between affect, risk propensity, and craving vary across static one-time and repeated within-day momentary assessments, and our data support this contention. Our findings showed no significant association between the traditional laboratory-based assessment of risk propensity and our momentary EMA measure. Alternatively, our sample consisted of adolescents and, although negative-affect-induced craving has received more empirical attention than positive-affect-induced craving for modeling relapse and the cyclical process of addiction in adults, positive affect may be particularly relevant for adolescents, as addictive processes are developing. In line with this, research on drinking motives among adolescents finds that younger drinkers are more prone to endorse motives to enhance positive affect or to be social than motives to cope with or decrease negative affect (see Kuntsche et al., 2006, for a review). Additional research is needed to better understand disparate findings for positive and negative affect in adolescents.

The present findings also add a growing body of research on the intersection between affect and risk-prone behavior. In previous work, authors caution that impulsive or risky behavior must be considered as a multifaceted construct, and its relationship with craving must be interpreted in the light of the role of negative and positive urgency, i.e., the tendency to engage in rash action in response to strong positive or negative affect (Cyders & Smith, 2008). The tendency for risk-taking or rash action in response to extreme emotional states is a strong predictor of alcohol use and consequences (Coskunpinar et al., 2013). As a trait, emotion-based risk-taking propensity predicts onset of, and increase in, alcohol use across the adolescent and early adult years (Smith & Cyders, 2016). The present work combines EMA methods of self-reported, momentary emotional states and behavioral assessments of risk-taking propensity using a task adapted from laboratory analogs. Results support the notion that the valence of affect is relevant to its moderating role linking risk-taking to alcohol craving in adolescents.

Leveraging EMA to model in-the-moment variability in constructs traditionally studied as stable, individual-difference variables in the human laboratory affords the opportunity to advance our understanding of how core features of addiction unfold in real-time and real world settings. Together with recent work by MacLean et al. (2018), the present study moves assessment of risk-taking propensity from the laboratory to natural settings. Adding to MacLean et al. (2018), we identified a large degree of within-person (i.e., moment-to-moment) variability in risk-taking propensity using an EMA-delivered measure, providing additional support for the importance of identifying contextual factors that impact momentary fluctuations in risk propensity. This consistency across studies is noteworthy given key differences between these mobile tasks.

MacLean et al. (2018) captured risk-taking propensity through continued button press to simulate additional pumping. Using this approach, which is modeled after sequential risk-taking paradigms where respondents choose between risky and safe play options in a serial of successive trials, participants press and hold a button to indicate their level of risk. There is appeal to the continued press approach, as it maintains a sense of agency over the choice to engage in additional pumping. In the present study, however, participants completed an automatic risk propensity task via EMA that mirrors laboratory work by Pleskac et al. (2008). In contrast with sequential risk-taking approaches, adolescents entered a 3-digit number of directly on the handheld device to indicate the number of "pumps" they want to play. As described by Pleskac et al. (2008), this approach has some advantages over sequential paradigms. It maximizes the reliability of the data by examining the full range of responses across all trials. Sequential risk-taking tasks cannot observe the full range of possible responses when trials end in failure (e.g., balloon bursts), leaving how many more risks the respondent intended to take unknown. In addition, automatic trials afford quick responding, involve less motor requirements (e.g.,

entering three digits vs. clicking or holding a button), and require the same motor and cognitive effort for low- and high-risk response options. These advantages are particularly relevant for EMA, where respondents often have limited time and competing demands that may diminish the ability to sustain attention, especially for adolescents. Comparisons of automatic and sequential approaches suggest the automatized version provides unbiased estimates and maintains predictive validity of substance use (Pleskac et al., 2008).

Several limitations of this study are important to consider when interpreting the findings. First, our ability to elucidate associations among focal variables is inherently limited by the short duration (i.e., 1-week) of the EMA monitoring period. Although results support a stronger link of risk-taking propensity and alcohol craving during heightened states of positive, but not negative affect, it is possible that associations for negative affect would emerge with a longer EMA period. Second, we studied a sample of teenage problem-drinkers, the majority of whom met diagnostic criteria for an AUD, who enrolled in a clinical trial designed to test the effects of a medication on alcohol craving and use. Consequently, our findings may not generalize to the broader scope of adolescent drinkers. Third, although leveraging EMA to identify within-person variability in risk-taking among adolescents is innovative and a strength of this work, our approach has limitations. Our single-trial approach, designed to facilitate quick and easy responding and maximize compliance rates, precluded our ability to examine popular strategies for estimating different aspects of risk-taking performance, including investigating the coefficient of variability (DeMartini et al., 2014). Variability across EMA single-trial administrations was conflated with variability due to within-person contextual differences. Future research should further investigate the optimal number of trials to maximize sensitivity to between- and within-person differences while still maintaining feasible in terms of participant burden and compliance. Finally, our sample size is small; an important goal for future research is to replicate these findings in a larger sample and to more directly examine individual difference factors that influence these associations, such as sex and age.

On balance, the present work contributes new information about the momentary unfolding of complex relations among affect, risk propensity, and alcohol craving in adolescents' daily lives by adapting a laboratory-based behavioral measure of risk-taking propensity. Alcohol craving and risk-taking propensity are well-vetted markers of addiction with strong relevance for adolescents. Both constructs have theoretical and empirical ties to momentary fluctuations in emotional states. Our findings support the notion that acute changes in mood and risk-taking propensity interact to predict acute increases in craving among adolescent problem drinkers. Although additional research is needed to understand whether these phenomena exert causal influences on alcohol craving, our findings underscore the importance of momentary affect and risk-taking propensity for understanding fluctuations in craving and implicate a possible mechanism by which risk propensity confers liability for addiction. This work also supports the utility of EMA methods for disentangling underlying mechanisms of AUD among adolescents and highlights the value-added approach of disaggregating the momentary and trait-like components of affect and risk-taking propensity to understand acute changes in craving. On the whole, this approach affords a novel opportunity to generate testable hypotheses about dynamic associations among intrapersonal and environmental influences on craving among adolescents and examine their impact on alcohol use and misuse. Advancing our ability to identify contexts that drive craving or motivate alcohol consumption would help inform the development of targeted intervention strategies.

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