Emotional Distress May Increase Risk for Self-Medication and Lower Risk for Mood-related Drinking Consequences in Adolescents

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The current study examines indicators of emotional distress and coping that may define sub-populations of adolescents at risk for two potential affect-related mechanisms underlying substance misuse: self-medication and mood-related drinking consequences. Although theory and empirical evidence point to the salience of affect-related drinking to current and future psychopathology, we have little knowledge of whether or for whom such mood-related processes exist in adolescents because few studies have used methods that optimally match the phenomenon to the level of analysis. Consequently, the current study uses multi-level modeling in which daily reports of negative mood and alcohol use are nested within individuals to examine whether adolescents with more emotional distress and poorer coping skills are more likely to evidence self-medication and mood-related drinking consequences. Seventy-five adolescents participated in a multi-method, multi-reporter study in which they completed a 21-day experience sampling protocol assessing thrice daily measures of mood and daily measures of alcohol use. Results indicate that adolescents reporting greater anger are more likely to evidence self-medication. Conversely, adolescents displaying lower emotional distress and more active coping are more likely to evidence mood-related drinking consequences. Implications for identifying vulnerable sub-populations of adolescents at risk for these mechanisms of problematic alcohol use are discussed.

Keywords: Adolescence, Alcohol, Self-Medication, Negative Affect, Experience Sampling

Introduction

Affect-motivated drinking patterns are particularly salient mechanisms of drug misuse to examine in adolescents because of their relation to heavy and problematic alcohol use in adulthood (Cooper, Russell, and George, 1988). Indeed, the vast majority of individuals who eventually become dependent in adulthood begin

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taking drugs in adolescence (Kassel et al., 2010), and the age at which individuals initiate alcohol use is related to alcohol misuse in late adolescence (Hawkins et al., 2007). In addition, the adolescent developmental period is characterized by neurological growth and change, particularly in areas of the brain that are related to reward reinforcement systems and emotional cognitions and reactivity (Steinberg, 2010). Thus, an underdeveloped and rapidly changing executive control system during adolescence may contribute to engagement in risky behaviors, including drinking alcohol, which can in turn compromise the same developing brain system (Riggs and Greenberg, 2009; Wiers et al., 2007). Consequently, better understanding the relationship between affective experiences and drinking patterns are of critical importance to our understanding of developing patterns of alcohol use and misuse throughout adolescence and adulthood.

Indeed, the relation between negative affect and drinking continues to cultivate notable interest, despite mounting evidence that the two are only weakly associated (Baker et al., 2004). One possible explanation for this weak association is a lack of attention to underlying mechanisms. Although self-medication, or the use of alcohol as a means of alleviating negative emotional experiences, is a prominent mechanism offered to account for this association (Greeley and Oei, 1999), other mechanisms may act in concert or in place of self-medication. For example, drinking alcohol may have various mood-related consequences for adolescents that then serve to either deter or positively reinforce drinking behaviors. A second explanation for the weak association could be that only a sub-population of vulnerable youth engages in affect-related drinking. Chief among the potential moderators underlying this vulnerability are a) *emotional distress*, that is adolescents who experience overall higher levels of negative emotions or affective states, and b) ineffective *coping style*s, which may indicate poorer ability to effectively deal with negative affect or resulting consequences of drinking behaviors. In the current study, we tested two mechanisms – self-medication and mood-related drinking consequences - that may act singly or in concert to explain the association between negative affect and drinking in adolescents and whether emotional distress and coping style served as moderators of these associations.

The self-medication model.

Evolving out of the tension-reduction hypothesis offered by Conger (1956), the self-medication model in part posits that drinking is a motivated behavior aimed at reducing negative, stressful or aversive states. Many studies evaluating this model in adolescent samples rely on cross-sectional or multi-year longitudinal designs that either examine contemporaneous associations between mood and drinking (which are unable to disentangle either of the mechanisms of interest here) or associations between mood and drinking six months to years later (which is temporally inconsistent with the self-medication mechanism). In both adults and adolescents, such studies provide only weak support for this association (Greeley and Oei, 1999; Halfors et al., 2005; Sayette, 1999; Tschannet al., 1994). In addition, many use coping motives as an underlying motivation factor that indicates self-medication.

Recent studies using temporally informative designs (e.g., experience and event sampling, diary-based

assessments) are better suited to test the phenomena of interest for several reasons. First the temporal spacing of assessments is more matched to the daily (not monthly) hypothesized processes of self-medication. Second, such assessments do not rely on an individual being consciously aware of his or her coping motives to drink, as do studies that use self-reports of coping motives to test for self-medication. Indeed several leading theories and lines of research on processes of addiction outline a progression of addiction in which negative affective cues and coping motives become classically conditioned as part of a subconscious process (Baker et al., 2004; Kassel et al., 2010). Consistent with the development of self-medication processes at a subconscious level are several studies that have found that self-reported coping motives do not predict observed associations between negative affect and drinking behaviors (Hussong, Galloway, and Feagans, 2005; Tennen et al., 2000). Consequently the use of experience sampling methods that assess observed mood and drinking behaviors in a more temporally consistent manner may provide the best tests of such processes.

Studies using temporally-informed designs with college and adult samples have shown short-term (within day or over 1-4 days) covariation in mood and drinking (Hussong et al., 2001; Park, Armeli, and Tennen, 2004). Only recently have a few studies extended these methods to test self-medication processes in adolescents. Results of these studies have not supported the covariation between negative mood and substance use more generally in adolescence. However, these studies have found stronger co-variation for some sub-populations of adolescents including those reporting lower levels of conduct problems and those with less parental social support and more dismissive parental reactions to adolescents' emotions (Hersh and Hussong, 2009; Hussong et al., 2008; and Reimuller, Shadur, and Hussong, 2011). Consequently, within the small extent literature using temporally appropriate methods of assessment, findings suggest that certain emotion and behaviorally-based variables may help define which adolescents are at greater risk for self-medication.

A drinking consequences model.

That drinking impacts mood is supported by previous experimental studies suggesting a biphasic effect of alcohol on emotional arousal such that early in a drinking episode, during the ascending limb of the blood alcohol curve, individuals feel increased arousal and positive affect, whereas later in a drinking episode or during heavy drinking, in the descending limb of the blood alcohol curve, they feel decreased arousal and perhaps increased negative affect (Pohorecky, 1977). Negative emotions may also result from the side effects of drinking heavily, ranging from hangovers or physical upset to withdrawal symptoms associated with addictive processes (Baker et al., 2004; Kushner, Abrams, and Borchardt, 2000).

In addition to such physiological effects of alcohol on mood, negative affect may be a psychological consequence of drinking-related events on adolescents' lives. Teens who engage in behaviors that are risky (e.g., risky sexual behavior or physically dangerous acts) or who incur sanctions (e.g., legal repercussions or parent conflict) may experience emotional distress secondary to the behaviors they engage in during drinking episodes (Windle, 1999). As such, for youth who engage in such styles of drinking, alcohol use may be a precursor to negative emotions or even depression (Hallfors et al., 2005). Hussong and colleagues (2001) used

a daily reporting strategy to offer support for this prediction, showing that periods of drinking in under-aged college students were followed by elevated guilt, hostility and sadness. Although underlying physiological and socially-embedded mechanisms cannot be disentangled in field-based studies of adolescent drinking, both suggest that negative affect may result from preceding alcohol use.

Only one study has examined a consequences model in adolescents using more temporally informative methods of experience sampling. This study found no support for the overall covariation of drinking with next day negative mood. However, adolescents with lower levels of conduct problems showed greater risk for next day negative affect (Hussong et al., 2008).

The moderating role of emotional distress and coping

Consequently, the limited evidence that exists using daily reporting methods thus far yields some support for these two underlying mechanisms of alcohol use operating in college students, but not during middle adolescence. Rather, daily associations between negative mood and drinking in adolescents appear to be operating for a select sub-population of youth. This is consistent with a reformulated self-medication theory that incorporates aspects of social learning theory as well as stress and coping models of health behavior to identify for whom alcohol use is likely a means of regulating affect (Greeley and Oei, 1999; Sayette, 1999). Both emotional distress and poor coping strategies may help define such a vulnerable sub-population of youth.

Indeed previous research indicates that emotional distress plays a role in the development of adolescent alcohol use, particularly patterns of problematic use (Colder et al., 2002; Hawkins, Catalano, and Miller, 1992). Adolescents who display higher levels of emotional distress are less likely to regulate their emotions effectively and are more likely to select unsuccessful coping strategies, resulting in maladaptive outcomes (Cooper et al., 2003; Laurent, Catanzaro, and Callan, 1997; Wills et al., 2001). Consequently, these deficits may create a particular vulnerability to affect-motivated drinking, as posited in the self-medication hypothesis. While research supports the prospective relationships between higher overall levels of negative affect (Wills et al., 1999), greater variability in affective states (Crowe et al., 1998; Mayer, 1988) as well as more maladaptive coping styles (Fromme and Rivet, 1994) and drinking in adolescents, such relations have yet to be examined using temporally-informed designs that provide better-suited tests of self-medication processes.

In addition, mood and drinking may show bi-directional relations such that, as predicted by multiple theories of addiction (Baker et al., 2004), a negative reinforcement cycle forms in which drinking becomes both a means to cope with triggering negative affect but also a means for increasing subsequent experiences of negative affect (Hussong et al., 2001). This may occur because for those already evidencing emotional difficulties, alcohol may exacerbate this problem by leading to more problematic styles of alcohol use (e.g. heavier drinking episodes) needed to experience the short-term stress-dampening effects of alcohol. Thus, we expect indicators of emotional distress and poor coping to moderate the self-medication mechanism, within which negative affect is a putative etiological factor underlying affect-drinking associations, to a greater extent

than they moderate the drinking consequences mechanism.

The current study

The current study tests the hypothesis that adolescents who display higher levels of emotional distress and deficits in their ability to cope with distress may be at greater risk to drink on days in which they experience heightened negative mood (indicative of *self-medication*) and at increased risk to experience negative mood as a result of drinking episodes (indicative of greater *drinking consequences*) potentially due to their lower capacity to manage or recover from the aftereffects of drinking episodes. We used a multi-method, multi-reporter strategy to examine these mechanisms in an elevated risk sample preparing for the transition to high school, a time generally considered stressful for adolescents that offers opportunities for social reorganization and new peer affiliations (Brown, 2004) as well as increased access and acceptability of alcohol use (Johnston et al., 2009). Thus, this developmental period may be a time in which some affect-drinking associations, potentially indicative of self-medication or consequence mechanisms, begin to emerge and become more evident.

Method

Participants

Participants were recruited through a two-stage design. In the first stage, 399 of 436 8th grade students in participating schools completed classroom-administered surveys assessing a broad array of factors. To increase the potential for assessing drinking behavior in adolescents, we recruited participants for stage two according to their rank-ordering of risk status (i.e., from high to low). Risk status was based on self-reported lifetime alcohol use, current drinking (i.e., in the past six months) and peer drinking, with endorsement of all three forming the highest risk category [1]. We attempted to contact 169 elevated risk participants (i.e., those endorsing at least one risk criterion) as well as an additional 27 non-risk participants during a time-limited recruitment period. (This stage required completion during the summer, between 8th and 9th grade, due to the intensity of the experience sampling paradigm and concerns with maintaining privacy in a school setting. Thus, we limited recruitment efforts to an eight-week period.) Primary reasons for non-participation were inability to contact (n=33), ineligibility (n=21, language barrier, moving, did not pass grade, child death), limited availability (n=17), discomfort with the sampling paradigm (n=5), and privacy concerns (n=11). (N=28 non-participants provided no reason.) Study participants were 81 adolescents, with 90% endorsing at least one risk indicator in stage one, resulting in a participation rate of 41% of those targeted for recruitment (n=196) or 57% of those eligible and contacted for recruitment (n=142).

Participants in stage 2 completed a multi-component battery over three weeks. In the current study, our sample included those who completed relevant measures in the stage 2 battery, or 75 participants. This sample was 45% male and 55% white, 20% black, 21% multiracial and 4% other. Adolescents had an average age of 13.6, with 16% of parents having a high school education or less and 55% of parents having at least a

college education. Eighty-nine percent of participants reported initiating or having friends who had initiated substance use, reflecting our intention to oversample youth at risk for drinking. As expected, participants in the analysis sample (N=75) differed from their peers in stage 1 (N=324) by reporting more frequent alcohol use ($t(393)=5.01$, $p<.001$; $M=1.48$ vs. 0.67) and more friends who used substances ($t(393)=3.11$, $p<.01$; $M=0.98$ vs. 0.65) as well as higher levels of depressive symptoms ($t(395)=3.58$, $p<.001$; $M=0.65$ vs. 0.44), delinquency ($t(394)=2.62$, $p=.01$; $M=0.50$ vs. 0.32), physical aggression ($t(394)=3.03$, $p<.01$; $M=0.75$ vs. 0.47), and, to some extent, non-physical conduct problems ($t(393)=1.91$, $p=.06$; $M=0.85$ vs. 0.67). There were no gender differences ($\chi^2(1$, N=399)=1.84, $p=.18$), although stage 2 participants were more likely to be ethnic minority ($\chi^2(1$, N=399)=6.55, $p=.01$) than were those in stage one. As such, we successfully recruited an elevated risk sample.

Moreover, participants in our analysis sample (N=75) were more likely than the remaining adolescents targeted for stage 2 participation (N=121) to be ethnic minority ($\chi^2(1$, N=196)=4.90, $p<.05$) and female ($\chi^2(1$, N=196)=5.20, $p<.05$) as well as somewhat more likely to be depressed ($t(193)=1.72$, $p<.10$; $M=.65$ vs. 0.52). There were no recruitment biases as a function of peer substance use ($t(193)=-1.12$, $p>.10$; $M=1.06$ vs. 1.21), adolescent alcohol use ($t(192)=-1.07$, $p>.10$; $M=1.48$ vs. 1.71), delinquency ($t(193)=-0.29$; $M=.50$ vs. 0.53), physical aggression ($t(193)=-0.38$; $M=.75$ vs. 0.80), or non-physical conduct problems ($t(192)=-0.80$; $M=.85$ vs. 0.95). Thus, our analysis sample is highly representative of our targets for recruitment on key indicators of substance use, though it may over-represent adolescents with depression as well as female and ethnic minority adolescents.

Procedures

Seven of nine schools housing 8th graders in a rural, school district participated in the first stage of the study. Parents were informed about the study through letters mailed to their homes (as well as sent directly home with students) and were asked to contact the PI if they did not want their children invited to participate in the study. Information about the study was made available for parents to review in each school. Pairs of research assistants conducted classroom-based assessments of 8th graders in which they explained the study to students, obtained informed consent, and administered surveys. Teachers were invited to stay during testing but were asked not to interact with students to protect confidentiality. Students received a token gift and schools received a financial gift for participating in the study. One make-up day per school was also held to assess students absent on the original testing day.

In the second-stage of the study, adolescents and their parents were recruited via mail and phone. Participants completed a three-week protocol. At the initial visit, pairs of research assistants met with the adolescents and one of their parents either in their homes or at the university. Research assistants obtained written consent and assent and interviewed parents and adolescents in separate rooms, using a white noise machine to protect privacy. Adolescents completed a computer-administered interview in which research assistants read aloud questions and adolescents entered their responses privately. Sensitive questions,

concerning substance use, were administered via an audio-casi procedure. Research assistants also read aloud questions to parents who recorded their answers privately using paper-and-pencil methods. Adolescents and their parents each received $15 for completing this interview.

At the end of the initial interview, adolescents received instructions in an experience sampling protocol. Research assistants provided adolescents with a watch pre-programmed to sound four times daily over the next three weeks. Affixed to the back of the watch was a pouch containing a brief survey. Participants used attached stickers to rate their mood for each of three daily alarms. These three alarms were set at randomly selected times between 10AM-2PM, 2PM-6PM, and 6PM-10PM to capture varying mood over the day. The fourth alarm was set at 10PM to remind participants to complete daily substance use ratings. If participants were in the middle of drinking or planning to drink later in the evening they were instructed to wait until they went to bed that evening or the next morning to report the total number they drank that evening. Participants were also instructed that one drink of alcohol is equal to a 12 ounce beer, a shot of hard liquor or a mixed drink or an 8 ounce glass of wine. For confidentiality, these ratings were obscurely coded and stored in a private place in the home identified by the adolescent. Adolescents were also encouraged to call the research project toll-free each evening to read their data for the day as a back-up system for lost data. Adolescents received $1 per day of recordings and were also entered in a lottery for three $30 prizes for each time they called in their data [2]. At the final interview, adolescents completed an hour interview, turned in their experience sampling materials, and received related incentives. Adolescents received $15 for participating in this interview.

Measures

Demographics. In stage 1, adolescents reported their gender and ethnicity. In stage 2, parents reported on mother and father educational status, with the higher of these two forming the parent education indicator. Table I displays the means, ranges, and correlations among these and other study variables.

Daily mood and drinking. In stage 2, participants completed three mood ratings at randomly sampled times throughout each of 21 days. Using a five-point scale, they rated their mood in the moment with items based on the Multiple Affect Adjective Check List – Revised (MAACL-R: Lubin, Denman and Van Whitlock, 1998). To ensure temporal precedence of affect over alcohol ratings, we defined daily negative mood prior to evenings, when most drinking occurs, by averaging ratings of worry, stress, sadness and anger on the first two reports of each of 21 days ($M=1.63$, $SD=.79$, range=1-5). The resulting daily reports of mood were adequately reliable (average $\alpha= .79$). In addition to retaining these daily reports as an index of negative mood, we also created an aggregate index by averaging within each person's reports of daily negative mood.

Alcohol use ratings occurred each evening. On a slip of paper for each day, participants placed stickers over a number (0 to 5+) to indicate the number of alcoholic drinks they had that day. For current analyses, daily alcohol use was dichotomized as use versus no use ($M=.03$, $SD=.18$). These ratings were used to test hypotheses about the self-medication and drinking consequences models. Correlations among these

ESM variables and primary questionnaire variables are reported in Table I.

To have complete data on a given day, an adolescent had to report on at least one of the first two daily mood ratings as well as the substance use rating for that evening. We had data for 87% (or 1310 out of 1500) of our days of assessment. The number of days of missing data per participant ranged from 0-20, however 90% of the sample reported at least 14 days of complete data, with an average of 18.3 observations per adolescent [3]. Drinking occurred on 43 out of 1310 observations. Just over one quarter (27%) of adolescents used some alcohol during the sampling period, and the frequency of use ranged from 5% to 50% of the total days. As expected for this elevated risk sample, these ratings are higher than retrospective 30-day reports of drinking in eighth graders within the Monitoring the Future Study (20%) (Johnston et al., 2009) and are highly consistent with retrospective reports of drinking corresponding to the timing of ESM protocol as assessed during the final visit of our stage 2 interview (36%; $\chi^2(1)=25.88$, $p<.001$).

Emotional distress and coping moderators.

Anger. Three items from the MAACL-R were used to assess anger by both parent and adolescent report (in the initial visit only). Although Lubin and colleagues (1998) demonstrated the utility of the MAACL-R with 7th grade students, challenging words were omitted for ease of comprehension in the current administration, leaving three items that assessed being angry, mad and furious. Participants responded based upon the past three months for the initial visit and for the past 3 weeks for the final visit on a three-point scale ranging from (0) hardly ever to (2) often. Items were averaged within reports to form the highly reliable scales used in subsequent analyses (α=.88 to .93; *M*=.88, *SD*=.45 for parent report and *M*=.80, *SD*=.51 for adolescent report).

Anxiety. Parents and adolescents answered 10 items from the Revised Children's Manifest Anxiety Scale (Reynolds and Richmond, 1978) to assess anxiety. Items were selected on the basis of Chorpita and colleagues (2000) and pilot testing showing high factor loadings on the underlying factor. Participants indicated the extent to which each statement was true of the adolescent using a yes (1) – no (0) format either in the past three months (initial visit at stage 2 for parents and adolescents) or past three weeks (final visit at stage 2 for adolescents). Parents' reports were based on a single stage 2 assessment (α=.80, *M*=.48, *SD*=.28) and adolescents' reports were based on a mean of the two stage 2 assessments (α=.81-.88, with *M*=.40, *SD*=.27 for the averaged reports).

Depression. Parents and adolescents (at both the initial and final interviews in stage 2) rated adolescents' depressive symptoms using the 13-item Short Mood and Feelings Questionnaire (see Angold et al., 1995; Messer et al., 1995 for supporting reliability and validity data). Participants indicated whether each symptom was true, sometimes true, or not true (0-2 scale) for adolescents in the past six months. Items were averaged within reports to form the highly reliable scales used in subsequent analyses (α=.88 to .93). The two reports by adolescents were averaged to form a self-reported depression variable (M=.44, SD=.38) in addition to the parent-report variable (M=.37; SD=.35).

Table I Descriptive Statistics and Correlations among Primary Variables of Interest

	Construct	Mean/% (SD)	Observed Range	1	2	3	4	5	6	7	8	9	10	11	12	13
1.	Adolescent gender	45%	---	---	-.02	-.03	-.07	-.11	-.19	-.12	**-.22**	-.06	**-.26**	-.01	***-.21***	.11
2.	Adolescent ethnicity	45%	---		---	-.08	-.16	.12	***-.20***	-.01	.03	.00	-.06	.04	.00	.06
3.	Parent education	2.59 (.97)	1-4			---	-.01	**.28**	.05	.09	.02	-.03	-.02	-.04	-.15	-.02
4.	Daily Negative Mood (Aggregated)	2.05 (.57)	1-3.11				---	.14	**.40**	**-.20**	**.39**	**.28**	**.41**	**.30**	**.37**	.17
5.	Daily Drinking (Aggregated)	0.04 (.09)	0-0.5					---	**.24**	-.01	**.36**	.12	.13	.02	***.20***	.10
6.	Avoidant coping	1.35 (.68)	0.22-3.11						---	.02	**.42**	**.27**	**.30**	.09	**.42**	**.29**
7.	Active coping	2.09 (.61)	0.58-3.17							---	**-.25**	**-.34**	-.07	-.18	-.06	**-.30**
8.	Adolescent-reported depression	0.44 (.38)	0-1.84								---	**.35**	**.69**	**.23**	**.50**	.15
9.	Parent-reported depression	0.37 (.35)	0-1.92									---	.14	**.56**	**.30**	**.45**
10.	Adolescent-reported anxiety	0.40 (.27)	0-1										----	.16	**.49**	-.10
11.	Parent-reported anxiety	0.48 (.28)	0-1											---	**.28**	**.31**
12.	Adolescent-reported anger	0.80 (.51)	0-2												---	***.21***
13.	Parent-reported anger	0.88 (.45)	0-2													---

Note. Bolded test statistics are significant at p<.05 and italicized bolded test statistics are marginally significant at p<.10. Gender was coded as 0=girls and 1=boys. Ethnicity was coded as 0=white and 1=ethnic minority. Parent education was coded as 0=some high school (hs), 1=hs grad, 2=some technical school/college, 3=college/tech/vocational grad, and 4=grad/professional school.

Coping style. Adolescents reported the degree to which they used certain forms of coping to deal with problems over the past three months (on a scale of 1-5) by filling out the Adolescent Coping Orientation for Problem Experiences (A-COPE: Patterson and McCubbin, 1987). *Avoidant coping* was assessed by nine items from the venting and avoiding subscales (α=.74, *M*=1.35, *SD*=.68) while *Active coping* was assessed using 12 items from the developing self-reliance and solving family problems subscales (α=.77, *M*=2.09, *SD*=.61).

Results

The self-medication model

We used non-linear multi-level modeling to test the self-medication hypothesis. A two-level model was estimated in which daily (ESM) reports of mood and alcohol use were nested within 75 individuals, yielding 1310 observations for our self-medication model and 1309 for our drinking consequences model. Because alcohol use was a binary variable, we used Proc Glimmix in SAS 9.2 (SAS Institute, 2009) to estimate our models with a logit link function. The baseline model tested the main effect of negative affect on

daily alcohol use by including daily negative mood (person-mean centered) and whether the assessment day fell on a weekend versus a weekday as level 1 time-varying covariates. Adolescent ethnicity, adolescent gender and (grand-mean centered) parent education were used as level 2 time-invariant covariates. In order to obtain unbiased between- and within- person effects of affect on daily alcohol use, we person-centered our level 1 negative mood predictor and included a level 2 predictor which was the average negative mood across daily reports for each person (Raudenbush and Bryk, 2002, pp.134). A random intercept was also estimated at level 2.

No within-person effect of daily mood on daily alcohol use was found (β=-.15, z=-0.56, p>.10), although a significant between-person effect of aggregated negative mood on daily alcohol use was found (β=1.30, z=2.36, p<.05). This finding indicates that variability in negative mood did not predict when (i.e., on days of higher negative affect than is typical for a particular person) a given individual will drink, but aggregated reports of daily negative mood did predict who was more likely to drink, namely those with greater average negative mood over the three weeks of assessment. Although there were no effects of adolescent gender or ethnicity on daily alcohol use, parent education was a significant predictor (β=0.93, z=2.62, p<.05), such that adolescents whose parents had more education were more likely to report drinking.

We next tested whether indicators of emotional distress and coping moderated the daily covariation between negative affect and drinking in the self-medication model. Eight models tested each of the proposed (grand-mean centered) indicators by adding to the baseline model the main effect of the level-two moderator and the cross-level interaction of the moderator with the time-varying effect of daily mood (see Table II for results). When significant interactions were found, we plotted the daily drinking-negative affect relation across levels of the moderator to determine the pattern of findings (plots available upon request). We found evidence of significant moderation for one indicator of emotional distress. Adolescents who reported greater anger (β=1.61, z=2.31, p<.05) showed an increased risk, relative to their peers, of drinking on days in which they experienced elevated negative mood, consistent with the self-medication model. While not directly suggestive of self-medication, greater adolescent-reported depression predicted a greater likelihood of drinking on any given day (β=1.94, z=2.40, p<.05).

The drinking consequences model.

We also used linear multi-level modeling to test whether alcohol use led to a greater likelihood of negative mood the following day (for a total of 1309 observations for N=75 participants). Because negative mood was a continuous variable that approximated a normal distribution, we used standard maximum likelihood estimation procedures in Proc Mixed in SAS 9.2. The baseline model tested the main effect of daily (ESM) alcohol use on next day (ESM) negative mood, including the weekday vs. weekend effect and a person-centered indicator of whether or not drinking occurred on the preceding day as level-1 time varying covariates. Child gender, child ethnicity, (grand-mean centered) parent education, and a (grand-mean centered) indicator of mean alcohol use during the observation period were included as level-2 predictors.

Thus, the base model paralleled that for our test of self-medication.

There was no significant within-person effect of daily alcohol use on next day negative mood (β=0.12, z=1.17, p>.10) nor significant between-person effect (β=1.08, z=1.41, p>.10). Adolescent ethnicity was a marginally significant predictor of daily negative mood (β=-0.24, z=-1.92, p<.10), with ethnic minority teens reporting lower daily negative mood in this sample. No other effects were significant.

Eight models then tested whether each of the emotional distress and coping indicators moderated these relations in the drinking consequences model (see Table II for results). Paralleling the self-medication model, we tested these moderation effects by adding to the baseline model the main effect of the level-2 moderator and the cross-level interaction of the moderator with the time-varying effect of daily alcohol use. Two indicators of emotional distress and one indicator of coping moderated the drinking consequences model. Adolescents with lower parent-reported depression (β=-0.54, z=-2.30, p<.05) and parent-reported anger (β=-0.43, z=-2.68, p<.01) showed an increased risk for negative mood on days subsequent to drinking than did their peers. In addition, adolescents who reported greater active coping (β=0.65, z=3.14, p<.01) showed an increased risk for negative mood on days subsequent to drinking than did their peers.

Table II Results of Multi-level Non-Linear (self-medication) and Linear (drinking consequences) Models

Predictors	Self-Medication Model						Drinking Consequences Model			
	Main Effects			Interactions			Main Effects		Interactions	
	B	OR	Z	β	OR	Z	β	Z	β	Z
Avoidant coping	0.72	2.05	1.40	0.34	1.41	0.72	**0.30**	**3.25**	0.03	0.20
Active coping	-0.11	0.90	-0.20	-0.12	0.89	-0.21	-0.07	-0.66	**0.65**	**3.14**
Adolescent reported depression	**1.94**	**6.96**	**2.40**	0.36	1.43	0.64	**0.58**	**3.45**	0.11	0.54
Parent reported depression	-0.73	2.08	-0.82	0.96	2.61	1.42	**0.38**	**2.22**	**-0.54**	**-2.30**
Adolescent reported anxiety	1.16	3.19	0.90	0.81	2.25	0.82	**0.79**	**3.56**	0.39	1.16
Parent reported anxiety	-0.88	0.41	-0.69	1.59	4.90	1.59	**0.60**	**2.88**	-0.14	-0.42
Adolescent reported anger	0.41	1.51	0.54	**1.61**	**5.00**	**2.31**	**0.34**	**2.83**	0.02	0.11
Parent reported anger	0.05	1.05	0.08	0.31	1.36	0.69	**0.30**	**2.26**	**-0.43**	**-2.68**

Note. All models also contained main effects of day of week (time varying covariate) as well as adolescent gender, ethnicity and parent education. Moderators were grand-mean centered. Bolded test statistics are significant at p<.05 and italicized bolded test statistics are marginally significant at p<.10.

Discussion

The current study examined whether indicators of emotional distress and coping style served to differentiate adolescents at risk for two underlying mechanisms of alcohol use and potential misuse: self-medication and drinking consequences models. The current study is one of only a handful of studies to test

these two mechanisms underlying negative affect-drinking association in adolescents using an experience sampling paradigm matched to the phenomena of interest. Specifically, we used within-person analyses to assess *whether* increases in an adolescent's level of negative affect on a particular day, relative to his or her typical level of negative affect, were associated with an increased likelihood of drinking alcohol on that day (for tests of self-medication). We used similar within-person models to examine whether drinking alcohol was associated with increased negative mood the following day (for tests of mood-related drinking consequences). Between-person moderators of emotional distress and coping were used to specify *for whom* these associations were present.

Findings provide preliminary support for the functioning of these mechanisms in a vulnerable sub-population of youth who evidence various forms of emotional distress or coping style. Specifically, results indicate that self-medication is more evident in adolescents who self-report greater anger. Counter to our prediction however, the effect of drinking on subsequent negative mood is mostly evident in adolescents who do *not* show signs of emotional distress, as indexed by less parent-reported depression and anger, and greater adolescent-reported active coping.

Emotional distress and affect-drinking relations

Results from the current study are consistent with accumulating evidence pointing to the self-medication model as limited in generalizability and perhaps most applicable to those with emotional liabilities and ineffective coping styles (Cooper et al., 1995; Laurent et al., 1997). In particular, adolescents who reported higher levels of anger emerged as a specific subgroup at-risk for self-medication. Notably this was the only indicator of emotional distress to emerge as significant, although parent-report anxiety and depression follow a similar pattern, although not reaching significance. In addition bivariate correlations show substantial associations between self-reported anger and anxiety (r = .49) and depression (r = .50), indicating significant overlap in these various emotional expressions of experienced distress. It may be that an internalizing presentation is characterized by more mixed presentation of anger or irritability at this developmental stage. Given the lack of consistency for any one indicator of distress, the general pattern of findings indicate distress more generally as a potential underlying vulnerability for self-medication in adolescents. Although replication of these analyses on larger samples of adolescents would enhance our confidence in this particular pattern of findings, such a pattern is consistent with previous research indicating that emotional distress plays a role in the development of adolescent alcohol use, particularly patterns of problematic use (Colder et al., 2002; Hawkins et al., 1992).

In contrast to the self-medication model, the drinking consequences model is not often considered in the larger literature and few studies even in adults utilize daily process methods to test this mechanism. Findings from the current study indicate that adolescents with greater active coping strategies and lower parent-reported depression and anger are more likely to evidence elevated negative mood on days following drinking. Thus, counter to prediction, emotional distress and more adaptive forms of coping generally served

to reduce risk for negative mood on days following drinking.

These findings are in line with previous work that shows that adolescents with fewer conduct problems are more likely to experience mood-related drinking consequences (Hussong et al., 2008). They are also worrisome in that less well-adjusted adolescents who evidence an insensitivity to the negative consequences of alcohol may engage in increasing levels of drinking over time in the absence of negative feedback (Newlin and Thomson, 1997). However, given the non-experimental nature of the current study it is equally plausible that indirect effects or mechanism are also at play. That is, negative mood could result, not directly from the physiologic effects of alcohol use, but from the indirect ramifications of socially awkward behavior or getting caught by parents. Indeed adolescents who are more well-adjusted may also have parents who monitor their behavior more and thus the behavioral consequences for drinking may be more severe than those who are less well-adjusted.

Potential reinforcement cycles

Taken together, these indicate a potential problematic cycle that may serve to accelerate problematic alcohol use. That is, a negative reinforcement cycle in which drinking serves to alleviate negative affect may be developing for emotional distressed youth. Consistent with this hypothesis, several longitudinal studies examining the pattern of drinking behavior across adolescents support emotional distress as increasing the likelihood heavy drinking or rapid escalation in drinking behaviors across the adolescent years (Colder et al., 2002; Power et al., 2005). At the same time, for youth who do not experience negative consequences for drinking this may become positively reinforced coping strategy, thus leading to higher levels of use. These forces may work in conjunction over time, such that the moderating effect of emotional distress is actually risk-promoting for the outcome of long-term vulnerability for alcohol use. Thus, this vulnerable population may best highlight the relation between negative cycles of behavior occurring at the daily level of analysis (self-medication and drinking consequence mechanisms) and a more stable, chronic pattern of affective symptomatology. As such, these findings highlight the greater need to understand self-medication processes within the larger context of other mechanisms underlying affect-drinking relations in affectively-challenged youth.

Importantly, no one indicator of emotional distress or coping emerged as a prominent marker or particularly reliable marker that identifies youth more likely to evidence self-medication or mood-related drinking consequences. These various forms of emotional distress were only modestly correlated with each other across reporter (ranging from $r = .16-.35$). This is consistent with research on measures of anxiety and depression that are typically less reliable at younger ages and show lower rates of inter-reporter agreement (De Los Reyes and Kadzin, 2008) and may be one of the reasons for the lack of consistency of effects for any one form of distress. Substantially higher were the correlations within reporter across the different forms of emotional distress (ranging from $r = .31-.69$) indicating some overlap in constructs, potentially related to underlying emotional dysregulation. However, not all of these forms of emotional distress identified which

youth were vulnerable to self-medication and mood-related consequences. Therefore, there may be unique liability of specific forms of distress, potentially related to sub-types of emotions (e.g. anger or sadness) or processes of risk that serve to further identify the most vulnerable youth.

Limitations and conclusions

Several methodological limitations should be considered alongside the strengths of the current study. First, the small sample size may limit the generalizability of findings to broader populations of adolescents and may have limited power to test hypotheses. Despite this later concern, repeated measures design of the daily sampling methods actually yields greater statistical power than that based on only two waves of data (Quene and van den Bergh, 2004). Moreover, support for moderated effects in the self-medication and drinking consequences models argue against low power as underlying these results. Second, low base rates of drinking during the three-week sampling window may have limited the within-person variability in drinking behavior which could, in part, account for the lack of support for the self-medication model but is not applicable to the higher observance of negative affect in our drinking consequences model. While potentially limiting the power of models, such low base rates of daily alcohol use are actually consistent with what we should observe for an elevated risk sample of rising ninth graders relative to national norms (e.g. Johnston et al., 2009). In addition, we dichotomized alcohol use and adopted appropriate techniques for this outcome, thus minimizing concerns related to the non-normally distributed outcomes associated with low base rate behaviors. Thus, methodological reasons do not clearly account for our pattern of results. However, these limitations require some caution in generalizing our findings prior to replication in future studies.

It is also important to note that because this is a correlational study, we cannot definitively conclude that within-person increases in negative affect are causing subsequent drinking behavior. As previously outlined, potential co-occurring mechanisms could be at play. For example, adolescents who are experiencing more negative affect could show corresponding increases in impulsivity, which in turn may promote hasty decisions to drink. However, alternate or co-occurring mechanisms do not necessarily negate the presence of self-medication as defined by an increased likelihood of drinking on days of increased negative affect. We feel the affective signal is likely part of a broader mechanism of risk that may include cognitive, motivational, and other response systems.

Finally, the current study did not take into account other forms of licit or illicit drug use or the heaviness of drinking occasions that could play a role in these processes. There is some support for the self-medication model in adolescents who experiment with cigarette smoking. Using ecological momentary assessment, Mermelstein and her colleagues have used daily measures of affect and cigarette smoking to show that adolescents who experiment with cigarettes report higher levels of negative affect and lower levels of positive affect before smoking episodes (Mermelstein et al., 2003; Turner, Mermelstein, and Flay, 2004). To our knowledge, no other research studies have examined adolescent self-medication or mood-related consequences mechanism using daily assessment methods for other types of licit or illicit substances.

Therefore, it will be important for future studies to examine whether evidence for these salient mechanism of adolescent substance use and misuse exist for other types of substances.

In conclusion, the current study adds to an important line of inquiry examining *for whom* affect-drinking associations emerge. In addition to understanding the relations among various mechanisms of risk, both person- and variable-oriented approaches to identifying vulnerable sub-populations of risk are needed. By working across these approaches, we can better understand the multiple dimensions that together identify homogenous, vulnerable sub-populations (in a person-oriented approach) but also the means by which these populations are at-risk (in a variable-oriented approach). By pursuing our understanding of inter-related mechanisms of risk and vulnerable sub-populations, we can improve prevention and treatment efforts through better identification of risk groups (i.e., vulnerable sub-populations), risk processes (i.e., alternative mechanisms) and protective and vulnerability factors (i.e., moderating factors) to reduce involvement in one of the more dangerous and addictive patterns of adolescent alcohol use, misuse, and affect-related drinking.

Acknowledgements

Endnotes

[1] The second level of risk (2) was defined by those reporting current and lifetime adolescent drinking, followed by those reporting (3) current adolescent drinking and peer drinking only, (4) current adolescent drinking only, (5) lifetime use and peer drinking only, and (6) lifetime drinking only.

[2] More sophisticated data collection devices for experience sampling incorporate palm pilot technologies capable of such benefits as time-stamping data, increased privacy and more complicated questionnaire administration. At the time of this study, such technology was available but poorly suited to the needs of adolescents on summer schedules. Our data collection devices had several advantages to increase compliance, including being waterproof (important to outdoor summer activities), wearable (no pens or pencils necessary, everything was affixed to a watch), easy to use and brief. No participants reported problems using the device and the oversized watches were even considered fashionable by some.

[3] Missing data across the 21-day period were primarily toward the end of the protocol, perhaps reflecting participant burden. There was no apparent day of the week trend in missing daily reports. Missing data for all pager contacts within a day were also fairly evenly distributed, with 16%, 18% and 19% missing data for the first three pager contacts of a day and 12% missing for nightly substance use reports. To increase confidence in the validity of these reports, we also developed a quality coding system for all daily assessments which is articulated fully elsewhere (see Hussong et al., 2008). For the current analyses, we only used data in which we were "confident" (99.5%), that is in which a participant clearly reported their mood or drinking in at least one form.

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