Published in final edited form as:
Alcohol Clin Exp Res. 2014 June ; 38(6): 1761–1769. doi:10.1111/acer.12415.

Changes in emotional reactivity and distress tolerance among heavy drinking adolescents during sustained abstinence

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Abstract

Background—Negative affect and low distress tolerance have been associated with increased likelihood of alcohol consumption and relapse. This study utilized the Paced Auditory Serial Attention Test (PASAT-C) Computer Version to examine affective reactivity, cognitive performance, and distress tolerance during early abstinence among heavy drinking adolescents.

Methods—Participants, ages 16–18 (50% female), were 23 heavy episodic drinking youth (HED) and 23 demographically-matched, non-drinking teens (CON). Both groups were drawn from the same schools and assessed at three time points: HED were first studied within 10 days (M = 4.26, SD = 4.4) of heavy episodic drinking and then at two 2-week intervals over four subsequent weeks of monitored abstinence. CON were studied at the same 2-week intervals.

Results—Findings indicate that HED responded with greater emotional response to the PASAT-C (i.e., greater increases in frustration and irritability and greater decreases in happiness) at the initial assessment, but their affective responses diminished with sustained abstinence. CON and HED task performance did not differ at the initial assessment or across time. HED showed faster task discontinuation times to the PASAT-C at the first assessment, and both groups reduced task persistence across testings. Among HED, greater lifetime and recent alcohol consumption,

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alcohol-induced blackouts, and withdrawal symptoms were associated with increases in negative affect with PASAT-C exposure. Earlier age of onset of alcohol use was linked to poorer performance.

Conclusions—Heavy episodic drinking adolescents demonstrated heightened emotional reactivity and poorer distress tolerance to a cognitively challenging task during early abstinence. The combination of elevated negative affect and low distress tolerance may place adolescents at a heightened risk for escalations in or return to alcohol involvement.

Keywords

adolescence; distress tolerance; negative affect; heavy episodic drinking; abstinence

INTRODUCTION

Current theoretical models of abuse and dependence posit that a propensity for stronger negative affect magnifies risk for progression to alcohol dependence (Abrantes et al. 2008; Tate et al. 2005) and that a stressor provokes additive risk for return to use among adults who recently completed treatment (Tate et al. 2005). In adults with substance use disorders, low tolerance for distress is predictive of treatment dropout (Daughters et al. 2005a) and shorter abstinence attempts (Daughters et al. 2005b). This progression from heightened negative affect and low distress tolerance to relapse may be due to expectations of both negative (i.e., reductions in negative mood) and positive (i.e., mood enhancement) reinforcement from substance intake (e.g., Koob and Le Moal 2008; Wills et al. 1995; Witkiewitz and Marlatt 2007). Such decisions to return to use or to continue to use are influenced by rational cognitive processes as well as by negative emotions that further direct behavior (Bechara and Martin 2004). Furthermore, individuals with low distress tolerance may have difficulty persisting in a task when experiencing negative emotions and rely on disengaging from the stressful activity to provide relief (Daughters et al. 2009). The prefrontal cortex, which is involved in decision-making and impulse control, undergoes continued development during adolescence and young adulthood (Giedd 2004). Therefore, the risk for impulsive decision-making associated with negative affective states and low distress tolerance is elevated in youth (Ernst and Fudge 2009), especially among teens who misuse alcohol or drugs (Clark et al. 2008).

Among adolescents with histories of alcohol problems, negative affect and low distress tolerance are associated with increased probability of alcohol use (Daughters et al. 2009). These factors are also considered risk factors for relapse among youth with alcohol use disorders (Ramo et al. 2012), especially during early abstinence when affective disruption is most pronounced (Brown et al. 1989a). Furthermore, protracted heavy drinking may provoke negative affect (Brown et al. 1995b; Liappas et al. 2002) and diminish problem-solving abilities (Brown et al. 2000; Goudriaan et al. 2007), thereby compromising distress tolerance and decision-making skills during this critical time. In the context of ongoing neurodevelopment, the combination of low distress tolerance, elevated negative affect, and a tendency towards negative reinforcement or reward-dependence may place abstaining adolescents at particularly heightened risk for return to problematic drinking.

Adult research has demonstrated that improvements in mood (Brown and Schuckit 1988; Brown et al. 1995a; Brown et al. 1991; Liappas et al. 2002) after sustained abstinence may contribute to decreased emotional reactivity and improved distress tolerance, but this possibility has not yet been explored in adolescent populations. To date, no study has investigated the rate and pattern of changes in emotional reactivity and distress tolerance during the initial days to weeks of abstinence from alcohol in heavy drinking youth (Brown et al. 2008). Elucidating the features of emotional improvements during early abstinence may have important implications for improvements in academic and social functioning among nonclinical heavy drinking youth, prevention, early intervention tailored to different stages of use and recovery, and reduction of problematic use among youth with alcohol use disorders.

Present Study

Many researchers have examined relapse phenomena via self-report outside of a relapse risk context, either using retrospective report of previous relapse events or in the context of longitudinal studies that utilize prospective reports (Maisto et al. 2002; Myers and Brown 1990), yet without proximity to the additive impact of stress. This study introduced an objective stressor to examine affective response, cognitive performance, and distress tolerance in heavy episodic drinking and non-drinking adolescents and to assess potential group differences and determine whether affective reactivity, performance, and distress tolerance improve over a four-week period following cessation of substance use in the heavy drinking youth. This study utilized a modified version of the Paced Auditory Serial Addition Test (PASAT-C; Lejuez et al. 2003) to provide a challenging cognitive task that assessed cognition (i.e., task performance) and generated negative affect in the context of an objective stressor to measure emotional reactivity (i.e., self-reported difference in affect after exposure to the challenging task). During the final stage of the PASAT-C, participants were provided the opportunity to persist in the task in the presence of negative affect or terminate the source of negative affect by quitting the task (i.e., task discontinuation). The PASAT-C created an opportunity to test a negative reinforcement model by employing a behavioral measure that provides measurable responses in close proximity to a stressor.

We expected that both heavy episodic drinkers and nondrinkers would evidence negative affect in response to the task; however, we hypothesized that heavy episodic drinkers with limited abstinence would show more pronounced affective responses that would improve as length of abstinence increased. We also predicted that heavy episodic drinking youth would show impacted cognition (i.e., worse task performance) and impulsive decision-making (i.e., quitting the task sooner), and that task performance as well as behavioral persistence would improve with extended periods of abstinence. Relations between emotional reactivity, task performance, distress tolerance, and alcohol use history were also explored.

MATERIALS AND METHODS

Participants

We were interested in studying youth with recent and frequent heavy episodic drinking who experienced recent withdrawal symptoms and had limited experiences with marijuana and

other drugs. Heavy episodic drinking was defined as ≥5 drinks in males or ≥4 drinks in females within a 2-hour period (NIAAA, 2002). We examined 23 heavy episodic drinking adolescents (HED; > 100 lifetime drinking episodes, > 3 past month heavy episodic drinking episodes, > 1 recent alcohol withdrawal symptom, < 50 lifetime marijuana episodes, and < 15 lifetime experiences with other drugs) and 23 control teens (CON; < 5 drinking episodes, no history of heavy drinking or alcohol withdrawal symptoms, no previous marijuana or other drug use). HED and CON, ages 16–18, were drawn from the same schools and matched on socio-demographic factors including age, gender (50% female), ethnicity (74% Caucasian), grades completed, recent grade point average, socioeconomic status (Hollingshead 1965), and family history of depression and of alcohol dependence in a first degree relative (Table 1). In accordance with the University of California, San Diego (UCSD) Institutional Review Board, written informed assent (for adolescents under 18) and consent (parent/legal guardian and teens 18 or older) were obtained prior to participation.

Recruitment and Eligibility Screening

Participants were recruited from local high schools, colleges, and community settings via mailings and fliers (Brown et al. 2005; Tapert et al. 2003). No information regarding alcohol or drug use criteria was described in the fliers or discussed prior to screening. Interested students responding by phone were independently screened to determine eligibility. All interested teens and their parents underwent a subsequent, detailed phone interview to confirm eligibility. To ensure findings were due to heavy drinking and not impacted by other factors shown to influence cognitive performance, emotional reactivity, or distress tolerance among youth, exclusionary criteria included history of alcohol dependence, non-alcohol related DSM-IV Axis I or II psychiatric disorder; extensive or recent drug use other than alcohol (i.e., not consistent with inclusionary criteria listed above); neurological dysfunction/trauma; serious medical illness; prenatal alcohol/drug exposure; sensory problems; and use of psychoactive medications.

Measures

Structured Clinical Interview and Substance Use History—Adolescent participants and their parents independently completed structured interviews to assess demographics, social and academic functioning (Brown et al. 1989b), family history of alcohol or psychiatric disorders (Family History Assessment Module Screener; Rice et al. 1995), and personal history of Axis I psychiatric disorders (Diagnostic Interview Schedule for Children; Shaffer et al. 2000). The Customary Drinking and Drug Use Record (Brown et al. 1998) and modified Time Line Follow Back (Sobell and Sobell 1992) documented teen substance use history, including lifetime and recent tobacco, alcohol, and drug use (12 types), withdrawal symptoms, DSM-IV abuse and dependence criteria, and other alcohol-related social and physiological problems.

Baseline Affect—To assess baseline mood state prior to PASAT-C testing, all participants completed the 20-item Positive and Negative Affect Scale (PANAS; Watson et al. 1988), a reliable measure of affective states with each rated from 1 (low) to 5 (high).

Paced Auditory Serial Addition Test - Computerized Version (PASAT-C)—

Participants completed the PASAT-C task (Lejuez et al. 2003) on three occasions at two 2-week intervals following cessation of alcohol use. During PASAT-C administration, numbers were presented on a computer screen, and participants were asked to add the number that was most recently presented with the number that appeared prior to it. The PASAT-C task presented three stages with varying latency between number presentation to (a) measure performance on a challenging neuropsychological test that involves working memory, attention, and arithmetic capabilities, and (b) introduce a cognitive stressor to assess negative emotional reactivity and distress tolerance. During the initial 'performance' stage, numbers were presented in 3-second intervals to assess a participant's ability to complete the task. During the second 'negative affect induction' stage, the latency period was decreased to 2 seconds to decrease participants' success rates and provoke negative affect. Prior to initiating the task and at the completion of the second stage, subjects were asked to rate their negative (anxiety, frustration, and irritability) and positive (happiness) emotional states on a visual analog scale ranging from 0 (none) to 100 (extreme) (Lejuez et al. 2003). Finally, during the third 'distress tolerance' stage, the latency period was further decreased to a 1-second interval and participants were offered the opportunity to persist with the task in the presence of negative affect or terminate the source of negative affect by discontinuing the task. In line with published work (e.g., Brown et al. 2002), *performance* was measured by the number of correct responses on the first stage, *emotional reactivity* was measured as the difference between pre-test affect and affect following the second stage, and *distress tolerance* was measured as time to discontinue the third stage as it indicated how long (in seconds) they were willing to persist in the presence of a cognitive stressor.

Assessment Timing and Abstinence Monitoring

HED and CON were assessed at three time points. HED were first studied within ten days of heavy episodic drinking (M = 4.26 days since last heavy episodic drinking episode, SD = 4.43) and then at two 2-week intervals over four subsequent weeks of monitored abstinence (2^{nd} testing session: M = 18.77 days since last heavy episodic drinking episode, SD = 4.96; 3^{rd} testing session: M = 32.12 days since last heavy episodic drinking episode, SD = 4.55). CON were studied at the same 2-week intervals. Abstinence was monitored thrice weekly via ETG/ETS alcohol metabolite (Wurst et al. 2006) and 10-panel drug urine testing, randomly determined breath samples (Intoximeter, St. Louis, MO), and self-report. Standardized sample collection procedures minimized the likelihood of participant tampering, and samples were analyzed by Redwood Toxicology (Santa Rosa, CA) using cloned enzyme donor immunoassay (CEDIA) kits. Abstinence was also facilitated using a standardized Motivational Interviewing protocol (Miller and Rollnick, 1991) demonstrated to encourage the maintenance of abstinence for adolescents in prior research (Brown et al. 2005; Schweinsburg et al. 2005).

Participants were compensated for their time and abstention throughout the four weeks to maintain commitment and reward sustained abstinence, with a bonus for study completion to encourage continuation. Four HED drank alcohol between sessions 1 and 2 (detected via toxicology screen and confirmed with self-report) and data collected after their alcohol use were excluded from the present analyses. To minimize the impact of study participation on

subjects' daily lives, research staff worked closely with enrolled youth to select a one month period that did not conflict with birthdays, school events, or breaks. As this was not a treatment seeking sample, eligibility was not contingent upon a teen's expressed desire to quit drinking. Instead, participants were motivated by financial compensation and the opportunity to contribute to research.

Statistical Analytic Plan

Comparison of socio-demographic characteristics between groups was conducted on distributions, means, and standard deviations using chi-square tests for categorical variables and t-tests for continuous variables.

Primary analyses were carried out with linear mixed model analyses of repeated measures, with participants entered as a random term, time point (as a category), and an interaction between time point and group. This approach is used in similar situations as a repeated measures ANCOVA, except that the linear mixed model allows us to retain data for the four participants who dropped the study and had only one valid data point. The mixed model analysis provided a convenient way to model error structures among repeated dependent variables; we modeled the structure of the means using fixed effects, specified a covariance structure for both between and within subjects, and fit the means model accounting for specified covariates (Gelman and Hill, 2007; Rabe-Hesketh and Skrondal, 2005; Singer and Willett, 2003). Interactions were evaluated with likelihood ratio (LR) tests for the comparison of nested models. In this study, models with and without the interaction terms were evaluated with the LR tests whose sampling distribution approximates a chi-square distribution with degrees of freedom equal to the difference in degrees of freedom between the two models (Frees 2004). To be consistent with prior research (e.g., Brown et al. 2002) and to limit the impact of skill or affective responding in the analyses, we took a conservative approach and covaried for baseline mood state (PANAS) and task performance in the linear mixed models examining affective reactivity and distress tolerance. Because performance may be influenced by pre-task mood states, we included pre-task mood in analysis of the performance stage.

Secondary analyses examined the associations between alcohol use characteristics and affective reactivity, task performance, and time (in seconds) to discontinue the task in the distress tolerance stage. Due to non-normal distribution of alcohol use characteristics and task discontinuation times, Spearman’s correlations were calculated to describe these relationships.

RESULTS

Affective response and changes with abstinence

Initial analyses examined baseline mood states of HED and CON and although positive and negative mood varied across individuals (positive: 1.1 – 4.6; negative: 1.0 – 2.3), groups did not differ in pre-test mood states at any of the three testing time points (*p*'s>.16). As designed, the negative affect induction stage of the PASAT-C task provoked negative affect beyond baseline mood in both CON and HED with feelings of frustration, irritability, and

anxiety increasing and the positive feeling of happiness decreasing from the onset of the performance stage to our assessment time point following the negative affect induction stage (*p*'s<.003).

Linear mixed models, controlling for self-reported pre-task mood states (PANAS) and task performance (Stage 1), tested the primary hypothesis that adolescent, heavy episodic drinkers would have more pronounced affective response to the stressor at the initial assessment but that their affective response would reduce with sustained abstinence. LRTs were used to evaluate whether inclusion of the interaction term improved overall model fit; the LR (approximates chi square) was statistically significant for frustration (χ^2(2, N=46) = 6.73, *p*=.035), irritability (χ^2(2, N=46) = 9.84, *p*=.007), and happiness (χ^2(2, N=46) = 5.99, *p*=.050), as described in more detail below. However, differences in anxiety between HED and CON at time point one and across time did not reach statistical significance (*p*'s>.055). Raw data for all four affective measure difference scores are shown in Table 2; marginal means estimates are used for the three statistically significant affective measures in Figure 1.

Frustration

Both groups evidenced an increase in frustration when completing the PASAT-C. HED showed a 81% greater increase in frustration from pre- to post-testing than CON at time point one, when controlling for task performance and baseline negative mood (*b*(SE)=24.54(7.48), *z*=3.28, *p*=.001, 95% CI: [9.88,39.21]). HED reduced the intensity of their frustration response from the task across testing with a trend at time point two (*b*(SE)= −14.22(7.74), *z*=−1.84, *p*=.066, 95% CI: [−29.40,0.94]) and a statistically significant interaction at time point three (*b*(SE)=−19.95(7.81), *z*=−2.56 *p*=.011, 95% CI: [−35.25,−4.65]). While frustration reactivity of CON also decreased with time, CON did not show a statistically significant change over testing session in their frustration response to the task at time point two (*b*(SE)=−8.32(6.04), *z*=−1.38, *p*=.169, 95% CI: [−20.18,3.54]) or at time point three (*b*(SE)=−11.60(6.53), *z*=−1.78, *p*=.076, 95% CI: [−24.39,1.19]). Using the marginal means estimates from the model, HED showed a 61% reduction in the intensity of their frustration response to the task from the initial to the final testing, while CON showed a 40% reduction in their emotional response (Figure 1).

Irritability

Similar group and group×time point effects were evident for intensity of and change in irritability across testing sessions, while controlling for task performance and baseline negative mood. Both groups showed an increase in irritability following the PASAT-C task; however, HED showed a 86% greater increase in irritability in response to the task compared to CON at time point one (*b*(SE)=13.95(6.28), *z*=2.22, *p*=.026, 95% CI: [1.63,26.27]). HED reduced the intensity of their irritability reactions with a trend at the second time point (*b*(SE)=92212;12.00(6.40), *z*=−1.88, *p*=.061, 95% CI: [−24.53,0.54]) and a statistically significant interaction at the third testing session (*b*(SE)=−20.64(6.45), *z*= −3.20, *p*=.001, 95% CI: [−33.30,−8.00]). CON did not show a statistically significant change over testing session in their irritability to the task at time point two (*b*(SE)=−0.46(5.02), *z*= −0.09, *p*=.927, 95% CI: [−10.29,9.37]) or at time point three (*b*(SE)=−0.88(5.49), *z*=−0.16, *p*=.873, 95% CI: [92212;11.65,9.89]). Abstaining HED showed a 71% reduction in

irritability in response to the PASAT-C from the initial to the final testing session, whereas CON showed a 5% reduction in their irritability across testing sessions (Figure 1).

Happiness

Both groups demonstrated a decrease in happiness following PASAT-C exposure when controlling for task performance and baseline positive mood; however, a main effect for group was identified with HED evidencing 320% greater reductions in the change in happiness scores at time point one (*b*(SE)=−24.65(5.95), *z*=−4.14, *p*<.001, 95% CI: −36.31,−12.98]). HED continued to display a more pronounced decrease in happiness at each testing, but the intensity of their affective response diminished at time point two (*b*(SE)=10.36(6.75), *z*=1.54, *p*=.125, 95% CI: [−2.86,23.59]) and at time point three (*b*(SE)=16.78(6.82), *z*=2.46, *p*=.014, 95% CI: [3.42,30.14]). CON did not significantly change their happiness ratings over subsequent testing sessions at time point two (*b*(SE)= −0.49(5.21), *z*=−0.09, *p*=.926, 95% CI: −10.69,9.72]) or at time point three (*b*(SE)= −2.66(5.53), *z*=0.48, *p*=.630, 95% CI: −8.17,13.49]). HED showed a 60% reduction in the intensity of their response to the task from the initial to the final testing, while CON showed a 35% reduction in their emotional response across testings (Figure 1).

PASAT-C performance

Linear mixed models controlled for baseline mood when examining whether HED would obtain lower performance scores than CON on the PASAT-C (Stage 1) and demonstrate greater improvement in task performance over testing session. CON and HED showed a trend for an initial group difference (*p*=.066) with HED performing worse on the task. Contrary to the hypothesis, no group×time point interactions were statistically significant (*p*'s>.327; Table 3).

PASAT-C time to task discontinuation

To examine tolerance for distress, linear mixed models controlling for performance and baseline mood assessed PASAT-C distress tolerance stage discontinuation times to determine initial distress tolerance and possible increases in task persistence with extended abstinence of HED. All participants' Stage 3 duration times were included in the analyses. Five CON participants persisted for the full 600 seconds of Stage 3 at all three time points; two HED completed the full task at time point one and one HED completed the full task at time points two and three. Consistent with the hypothesis that HED would quit faster, HED showed shorter time to quit than CON on the distress tolerance stage at the first testing (*b*(SE)=−108.28(60.74), *z*=−2.11, *p*=.035). Of note, no significant group×time point interaction was observed for HED and CON Stage 3 discontinuation times at the second or third testing sessions (*p*'s>.101). At the initial time point, when participants first experienced the high level of difficulty of the distress tolerance stage, CON persisted 53% longer than HED. Both adolescent groups displayed a pattern of quitting the task more quickly across testing sessions (*p*<.01; Table 3). No participants quit the task prior to Stage 3.

Alcohol characteristics and affect, performance, and task discontinuation times among drinking youth

The relationship of HED youth family history of alcohol dependence and alcohol use characteristics to PASAT-C affective responses, performance, and persistence were examined using Spearman's correlations. While family history of alcohol dependence did not differ between groups and was not related to the dependent measures ($-.06 < rho\text{'s} < .12$, $p\text{'s} > .329$), alcohol use characteristics were related to PASAT-C response measures during early abstinence (Initial Testing) and with sustained abstinence (Final Testing). Given our sample of 23 HED, these correlations should be considered preliminary.

Initial Testing

At initial measurement, both the number of lifetime drinking episodes and number of heavy episodic drinking episodes were positively correlated with level of induction of negative affect on the PASAT-C task. For example, drinkers with greater lifetime exposure to alcohol showed larger increases in frustration ($rho = .55$, $p = .006$) and reductions in happiness ($rho = -.56$, $p = .006$) following exposure to the task. More frequent recent drinking (i.e., 45 days prior to starting study) was positively correlated with induction of anxiety in the task ($rho = .55$, $p = .006$). Greater frequency of blackouts from alcohol in the three months prior to starting the study was correlated with larger increases in frustration ($rho = .47$, $p = .030$) and irritability during the task ($rho = .46$, $p = .038$). At initial testing, PASAT-C measures of affect, performance, and task discontinuation times were not associated with days since use, age of onset, recent or lifetime withdrawal symptoms, or the highest quantity of alcohol consumed among HED.

Final Testing

At the third testing session, when the average length of abstinence was just over one month, HED with greater lifetime alcohol exposure still showed greater increases in frustration to the task ($rho = .54$, $p = .016$). Significant correlations also emerged for age of onset of regular alcohol use and recent withdrawals from alcohol in the week prior to starting the study. HED with earlier ages of onset of drinking showed worse task performance ($rho = .55$, $p = .021$), and HED with more recent alcohol withdrawal symptoms exhibited greater increases in frustration to the task at the third testing time point ($rho = .63$, $p = .007$).

DISCUSSION

Although preliminary, the present findings suggest that compared to nondrinking peers, adolescents with recent heavy episodic drinking (1) display greater negative affect responses and poorer distress tolerance in cognitively challenging situations during early abstinence and (2) become less emotionally reactive as abstinence continues. Recent heavy episodic drinking of these adolescents was associated with greater emotional reactivity to an externally produced stressful situation. Specifically, heavy episodic drinkers' affective responses to a cognitive stressor, with respect to frustration, irritability, and happiness, were initially more pronounced than those of peers with limited alcohol exposure, but the emotional reactivity of heavy drinkers diminished with continued abstinence. These findings suggest that heavy episodic drinking adolescents experience more emotional reactivity

during early abstinence and appear to become less reactive within 4–6 weeks of abstinence. These findings could reflect a return to functioning that existed prior to onset of heavy drinking, an experience of short-term positive responses to encouraging life events (e.g., end of transient withdrawal symptoms or positive reinforcement for behavior change), or other factors related to recent abstinence.

Heavy episodic drinking teens with greater lifetime and recent alcohol consumption as well as a greater frequency of recent alcohol-induced blackouts and withdrawal symptoms showed greater increases in frustration, irritability, and anxiety from the task compared to youth without drinking experiences. Even when the groups reacted with similar levels of frustration following one month of abstinence, teens with greater lifetime exposure to alcohol and with more recent withdrawal symptoms still showed a greater induction of frustration to the task. Thus, among adolescents, recent heavy drinking may be related to negative affect, and greater lifetime severity of alcohol involvement and withdrawal symptoms may relate to persistence of negative emotional states.

Contrary to our hypothesis, youth with and without histories of heavy episodic drinking did not differ significantly in their performance on the PASAT-C task at the initial session or across testing sessions, although drinkers consistently performed slightly worse than non-drinkers across time points. While the groups did not differ statistically in performance, teens who initiated regular alcohol use at an earlier age continued to show worse task performance even with sustained abstinence.

Lower distress tolerance was most evident during early abstinence for youth with a heavy drinking history. In the first week of abstinence, heavy episodic drinking adolescents quit the distress tolerance stage of the task an average of approximately 90 seconds earlier than nondrinking peers. The drinkers' behavioral response of quitting the task more quickly is consistent with prior adult and adolescent research showing that duration of recent abstinence is related to the ability to persist when facing a psychological stressor (Daughters et al. 2005b). These results suggest that youth with less than two weeks of abstinence may experience stronger emotional responses in challenging situations and that youth with low distress tolerance may have difficulty persisting in productive behavior when experiencing negative emotions and may rely on negative reinforcement (i.e., disengaging from stressful activities by quitting the task) to provide relief (Daughters et al. 2009). It is possible that heavy episodic drinking adolescents may focus on immediate gains (e.g., relief from negative affect by getting drunk) and attend less to the potential negative consequences of their behavior, which may be an important vulnerability factor in progression to or persistence of alcohol involvement (Ramo et al. 2012).

Interestingly, at the initial testing session, heavy episodic drinking teens with recent alcohol exposure showed poorer tolerance of distress, but they showed a different pattern than predicted at subsequent assessments. Contrary to the hypothesis, both groups of participants, regardless of drinking history, quit the task sooner with subsequent administration, and in fact may be learning that quitting earlier is more adaptive in this stage. The difficulty level of the distress tolerance stage, with one second inter-stimulus intervals, is very high and with repeated exposure youth may learn that this stage is unlikely to result in significant

point increases. Thus, while the initial administration of the PASAT-C may indicate poorer distress tolerance among recent heavy episodic drinkers, repeated administration of the PASAT-C may reflect youth expectations of the quit option, rather than distress tolerance alone.

This study is the first to examine changes in emotional reactivity and distress tolerance in relation to length of abstinence among heavy episodic drinking youth. The groups were comparable on demographic and family history of alcoholism dimensions, and the heavy drinking teens were studied prior to onset of alcohol dependence. The study also considered both affective and behavioral responses to a stressful situation. Nevertheless, these findings should be considered tentative as the sample size was modest, limiting generalizability and resulting in lower power to examine gender or ethnic differences. Replication of these findings with a larger sample would substantiate and strengthen these preliminary findings. The PASAT-C was designed to measure performance, change in affect, and distress tolerance in specific stages of the task (Lejuez et al. 2003), but participants may not have responded to the task as designed over repeated testings. There is a need for further research to distinguish the contributing factors in adolescent responses to the PASAT-C over repeated administration. Future studies might also consider including youth who continue to engage in heavy drinking (i.e., no abstinence protocol) but follow the same testing schedule, allowing a more direct test of the effects of abstinence on youth functioning and enabling a better understanding of the practice effects with this task.

The existing literature examining substance use and dependence suggests that intolerance of emotional and somatic sensations is a key mechanism driving continued use (Brown et al. 2002). While the effects are modest, this study is the first to illustrate heightened emotional reactivity and poorer distress tolerance to a cognitively challenging task in heavy drinking adolescents in early periods of abstinence. It is possible that the combination of elevated negative affect and low distress tolerance during early abstinence may be a mechanism whereby heavy episodic drinking heightens risk for progression to an alcohol use disorder or results in a return to use following periods of abstinence. This information may also be relevant for teachers, parents, and counselors to understand that youth with recent heavy alcohol exposure may show heightened emotional reactivity and poorer tolerance of distress. Students and young adults frequently encounter academically challenging or socially demanding situations, and those with recent heavy drinking may have more difficulty due to their reduced ability to manage their emotional reactivity and tolerate negative affect, which can also lead to disrupted interpersonal relations or heightened risk for impulsive decision making (Clark et al. 2008; Ernst and Fudge, 2009). Reductions in emotional reactivity with abstinence may contribute to improvements in academic and social functioning among nonclinical, heavy drinking youth.

The capacity to withstand aversive internal states, including negative emotions, is integral to daily functioning. Importantly, the emotional reactivity of heavy episodic drinking adolescents appears to reduce with continued abstinence. Additional research is needed to understand factors underlying and facilitating this improvement and whether interventions can further improve emotional reactivity and distress tolerance among youth during early periods of abstention. It may also be helpful for youth to know that it is typical to experience

heightened emotional reactivity and poorer distress tolerance during early periods of abstinence. This knowledge may encourage maintenance of abstention or a lower compulsion to consume alcohol if they feel confident that their emotional lability will reduce relatively quickly.

Acknowledgments

The authors would like to thank the participants and their families for their efforts during the study. We also would like to acknowledge Chase Wagner, Rachel Carter, Sidney Bennett, andthe UCSD undergraduate volunteers for their data management, recruitment efforts, and assistance with data collection.

Supported by the following NIAAA and NIDA awards: R21 AA017321 (PI: S. Brown), 5R01 DA021905-04 (PI: S. Brown) and T32 AA013525 (Fellow: N. Bekman; PI: E. Riley)

REFERENCES

Abrantes AM, Strong DR, Lejuez CW, Kahler CW, Carpenter LL, Price LH, Niaura R, Brown RA. The role of negative affect in risk for early lapse among low distress tolerance smokers. Addictive Behaviors. 2008; 33(11):1394–1401. [PubMed: 18684569]

Bechara A, Martin EM. Impaired decision making related to working memory deficits in individuals with substance addictions. Neuropsychology. 2004; 18(1):152–162. [PubMed: 14744198]

Brown RA, Lejuez CW, Kahler CW, Strong DW. Distress tolerance and duration of past smoking cessation attempts. Journal of Abnormal Psychology. 2002; 111(1):180–185. [PubMed: 11866171]

Brown SA, Anderson KG, Schulte MT, Sintov ND, Frissell KC. Facilitating youth self-change through school-based intervention. Addictive Behaviors. 2005; 30(9):1797–1810. [PubMed: 16111834]

Brown SA, Inaba RK, Gillin JC, Schuckit MA, Stewart MA, Irwin MR. Alcoholism and affective disorder: Clinical course of depressive symptoms. American Journal of Psychiatry. 1995a; 152(1): 45–52. [PubMed: 7802119]

Brown SA, Irwin M, Schuckit MA. Changes in anxiety among abstinent male alcoholics. Journal of Studies on Alcohol. 1991; 52:55–61. [PubMed: 1994124]

Brown SA, McGue M, Maggs J, Schulenberg J, Hingson R, Swartzwelder S, Martin C, Chung T, Tapert SF, Sher K, Winters KC, Lowman C, Murphy S. A developmental perspective on alcohol and youths 16 to 20 years of age. Pediatric. 2008; 121(4):S290–S310.

Brown SA, Myers MG, Lippke L, Tapert SF, Stewart DG, Vik PW. Psychometric evaluation of the Customary Drinking and Drug Use Record (CDDR): A measure of adolescent alcohol and drug involvement. Journal of Studies on Alcohol. 1998; 59(4):427–438. [PubMed: 9647425]

Brown SA, Schuckit MA. Changes in depression among abstinent alcoholics. Journal of Studies on Alcohol. 1988; 49(5):412–417. [PubMed: 3216643]

Brown SA, Stetson BA, Beatty PA. Cognitive and behavioral features of adolescent coping in high-risk drinking situations. Addictive Behaviors. 1989a; 14(1):43–52. [PubMed: 2718823]

Brown SA, Tapert SF, Granholm E, Delis DC. Neurocognitive functioning of adolescents: Effects of protracted alcohol use. Alcoholism: Clinical and Experimental Research. 2000; 24:164–171.

Brown SA, Vik PW, Creamer VA. Characteristics of relapse following adolescent substance abuse treatment. Addictive Behaviors. 1989b; 14:291–300. [PubMed: 2787585]

Brown SA, Vik PW, Patterson TL, Grant I, Schuckit MA. Stress, vulnerability and adult alcohol relapse. Journal of Studies on Alcohol. 1995b; 56(5):538–545. [PubMed: 7475034]

Clark DB, Thatcher DL, Tapert SF. Alcohol, psychological dysregulation, and adolescent brain development. Alcoholism: Clinical and Experimental Research. 2008; 32(3):375–385.

Daughters SB, Lejuez CW, Bornovalova MA, Kahler CW, Strong DR, Brown RA. Distress tolerance as a predictor of early treatment dropout in a residential substance abuse treatment facility. Journal of Abnormal Psychology. 2005a; 114(4):729–734. [PubMed: 16351393]

Daughters SB, Lejuez CW, Kahler CW, Strong DR, Brown RA. Psychological distress tolerance and duration of most recent abstinence attempt among residential treatment-seeking substance abusers. Psychology of Addictive Behaviors. 2005b; 19(2):208–211. [PubMed: 16011392]

Daughters SB, Reynolds EK, MacPherson L, Kahler CW, Danielson CK, Zvolensky M, Lejuez CW. Distress tolerance and early adolescent externalizing and internalizing symptoms: the moderating role of gender and ethnicity. Behaviour Research and Therapy. 2009; 47(3):198–205. [PubMed: 19135649]

Ernst M, Fudge JL. A developmental neurobiological model of motivated behavior: anatomy, connectivity and ontogeny of the triadic nodes. Neuroscience & Biobehavioral Reviews. 2009; 33(3):367–382. [PubMed: 19028521]

Frees, E. Longitudinal and Panel Data: Analysis and Application. New York, NY: Cambridge University Press; 2004.

Gelman, A.; Hill, J. Data Analysis Using Regression and Multilevel/Hierarchical Models. New York, NY: Cambridge University Press; 2007.

Giedd JN. Structural magnetic resonance imaging of the adolescent brain. Annals of the New York Academy of Sciences. 2004; 1021:77–85. [PubMed: 15251877]

Goudriaan AE, Grekin ER, Sher KJ. Decision making and binge drinking: a longitudinal study. Alcoholism: Clinical and Experimental Research. 2007; 31(6):928–938.

Hollingshead, AB. Two-factor index of social position. New Haven, CT: Yale University Press; 1965.

Koob GF, Le Moal M. Review Neurobiological mechanisms for opponent motivational processes in addiction. Philosophical Transactions of the Royal Society of London, Series B, Biological Sciences. 2008; 363(1507):3113–3123.

Lejuez CW, Kahler CW, Brown RA. A modified computer version of the Paced Auditory Serial Addition Task (PASAT) as a laboratory-based stressor: Implications for behavioral assessment. The Behavior Therapist. 2003; 26:290–293.

Liappas J, Paparrigopoulos T, Tzavellas E, Christodoulou G. Impact of alcohol detoxification on anxiety and depressive symptoms. Drug and Alcohol Dependence. 2002; 68(2):215–220. [PubMed: 12234651]

Maisto SA, Martin CS, Pollock NK, Cornelius JR, Chung TA. Nonproblem drinking outcomes in adolescents treated for alcohol use disorders. Experimental and Clinical Psychopharamacology. 2002; 10:324–331.

Miller, W.; Rollnick, S. Motivational Interviewing: Preparing People to Change Addictive Behavior. New York: The Guilford Press; 1991.

Myers MG, Brown SA. Coping responses and relapse among adolescent substance users. Journal of Substance Abuse. 1990; 2:177–189. [PubMed: 1967011]

National Institute on Alcohol Abuse and Alcoholism. Final Report of the Panel on Contexts and Consequences, Task Force of the National Advisory Council on Alcohol Abuse and Alcoholism. Bethesda, MD: Dept. of Health and Human Service; 2002. High-Risk Drinking in College: What We Know and What We Need To Learn.

Rabe-Hesketh, S.; Skrondal, A. Multilevel and Longitudinal Modeling Using Stata. College Station, Texas: Stata Press; 2005.

Ramo DE, Prince MA, Roesch SC, Brown SA. Varaition in substance use relapse episodes among adolescents: A longitudinal investigation. Journal of Substance Abuse Treatment. 2012; 43(1):44–52. [PubMed: 22112505]

Schweinsburg AD, Schweinsburg BC, Cheung EH, Brown GG, Brown SA, Tapert SF. fMRI response to spatial working memory in adolescents with comorbid marijuana and alcohol use disorders. Drug and Alcohol Dependence. 2005; 79(2):201–210. [PubMed: 16002029]

Rice JP, Reich T, Bucholz KK, Neuman RJ, Fishman R, Rochberg N, Hesselbrock VM, Nurnberger JI, Schuckit MA, Begleiter H. Comparison of direct interview and family history diagnoses of alcohol dependence. Alcoholism: Clinical and Experimental Research. 1995; 19(4):1018–1023.

Shaffer DP, Fisher P, Lucas CP, Dulcan MK, Schwab-Stone ME. NIMH Diagnostic Interview Schedule for Children Version IV (NIMH DISC-IV): Description, differences from previous versions, and reliability of some common diagnoses. Journal of the American Academy of Child and Adolescent Psychiatry. 2000; 39(1):28–38. [PubMed: 10638065]

Singer, JD.; Willett, JB. Applied Longitudinal Data Analysis: Modeling Change and Event Occurrence. New York, NY: Oxford University Press; 2003.

Sobell, LC.; Sobell, MB. Timeline follow-back: A technique for assessing self-reported alcohol consumption. In: Litten, RZ.; Allen, JP., editors. Measuring alcohol consumption: Psychosocial and biochemical methods. Totowa, NJ: Humana Press; 1992.

Tapert SF, Cheung EH, Brown GG, Frank LR, Paulus MP, Schweinsburg AD, Meloy MJ, Brown SA. Neural response to alcohol stimuli in adolescents with alcohol use disorder. Archives of General Psychiatry. 2003; 60:727–735. [PubMed: 12860777]

Tate SR, McQuaid JR, Brown SA. Characteristics of life stressors predictive of substance treatment outcomes. Journal of Substance Abuse Treatment. 2005; 29(2):107–115. [PubMed: 16135339]

Watson DL, Clark A, Tellegen A. Development and validation of brief measures of positive and negative affect: the PANAS scales. Journal of Personality and Social Psychology. 1988; 54(6): 1063–1070. [PubMed: 3397865]

Wills TA, DuHamel K, Vaccaro D. Activity and mood temperament as predictors of adolescent substance use: test of a self-regulation mediational model. Journal of Personality and Social Psychology. 1995; 68(5):901–916. [PubMed: 7776186]

Witkiewitz K, Marlatt GA. Modeling the complexity of post-treatment drinking: it's a rocky road to relapse. Clinical Psychology Review. 2007; 27(6):724–738. [PubMed: 17355897]

Wurst FM, Dresen S, Allen JP, Wiesbeck G, Graf M, Weinmann W. Ethyl Sulfate: a direct ethanol metabolite reflecting recent alcohol consumption. Addiction. 2006; 101:204–211. [PubMed: 16445549]

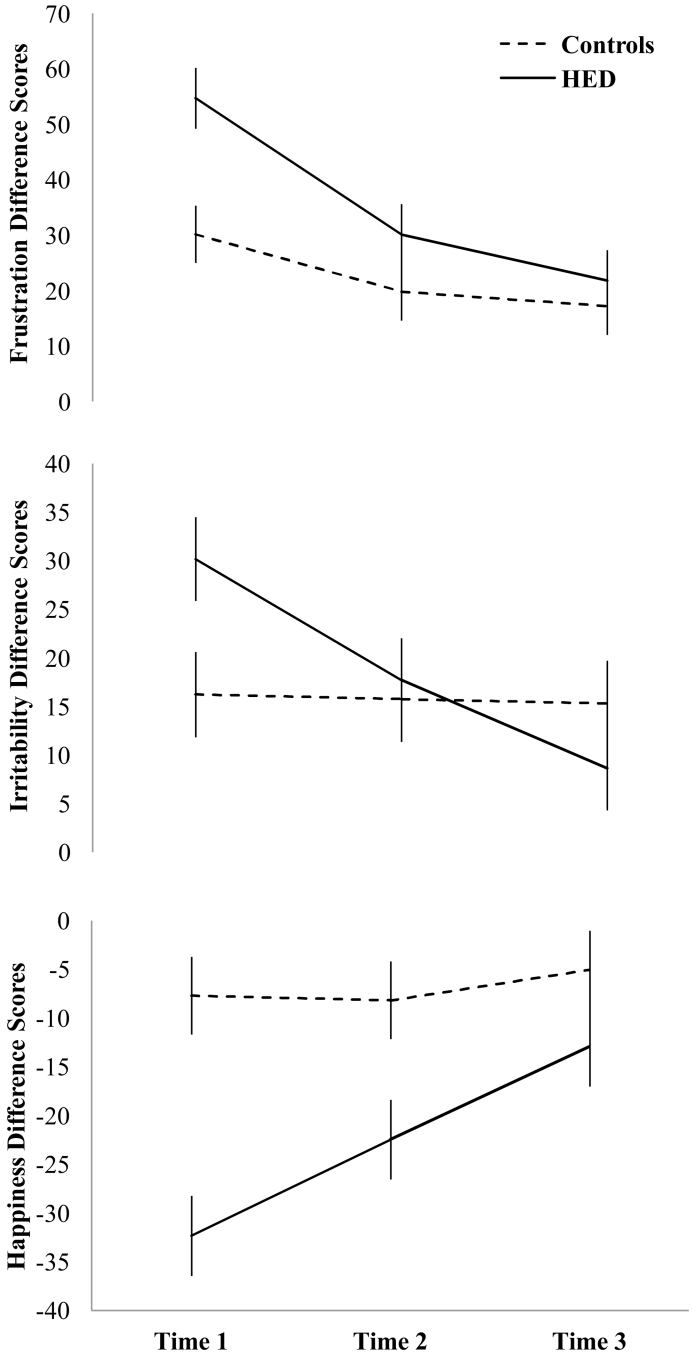

Figure 1.

PASAT-C frustration, irritability, and happiness marginal mean difference scores (i.e., affect following second stage minus pre-test affect) from linear mixed effects models with standard error bars, controlling for performance and baseline mood, by heavy episodic drinkers (HED; N=23 at Time 1 and N=19 at Times 2 and 3) and controls (N=23 at all time points) at three assessments over four weeks of monitored abstinence. Mean length of abstinence for HED = 4.26, 18.77, and 32.12 days at Time 1, 2, and 3, respectively.

Table 1

	CON N = 23; *M* (*SE*)	**HED** N = 23; *M* (*SE*)	***p*-value**
Age	17.7 (0.1)	17.7 (0.2)	0.184
Gender	11F, 12M	12F, 11M	0.616
Race (% Caucasian)	70%	78%	0.548
Grades Completed	11.0 (0.1)	11.1 (0.2)	0.236
Recent Grade Point Average	3.7 (0.1)	3.4 (0.1)	0.242
Hollingshead Code (SES)	20.9 (1.6)	23.2 (2.1)	0.172
Family History Alcohol Dependence	34%	48%	0.074
Family History Depression	52%	52%	1.000
Lifetime Alcohol Use [a]	0.7 (0.3)	166.6 (7.1)	< .001
Heavy Episodic Drinking Episodes in 3 Months Prior to Starting Study	0.0 (0.0)	16.1 (1.0)	< .001
Lifetime Marijuana Use [a]	0.0 (0.0)	31.4 (4.4)	< .001
Lifetime Other Substance Use [a]	0.0 (0.0)	5.1 (1.7)	< .001

[a]The term “lifetime use” refers to the number of days each substance was used in the participant's lifetime

Table 2

	Frustration Difference		Irritability Difference		Happiness Difference		Anxiety Difference	
	CON	HED	CON	HED	CON	HED	CON	HED
Time 1	31.7 (5.7)	54.9 (6.3)	17.6 (4.5)	32.2 (5.9)	−10.7 (3.9)	−30.4 (5.5)	13.7 (4.7)	24.2 (4.4)
Time 2	18.8 (4.3)	30.0 (6.2)	14.1 (3.6)	16.8 (5.7)	−8.4 (3.1)	−18.7 (5.5)	5.3 (2.5)	9.7 (3.4)
Time 3	15.3 (4.2)	23.5 (5.7)	12.7 (3.7)	11.0 (3.1)	−6.0 (2.5)	−11.1 (4.5)	3.1 (2.8)	10.7 (4.5)

Note: All data reported as *M* (*SE*). Mean length of abstinence for HED = 4.26, 18.77, and 32.12 days at Time 1, 2, and 3, respectively.

Table 3

	Performance (Stage 1)			Distress Tolerance Discontinuation Times (Stage 3)		
	CON	**HED**	***p*-value**	**CON**	**HED**	***p*-value**
Time 1	24.8 (2.5)	19.5 (2.3)	0.066	263.5 (44.4)	172.5 (44.4)	0.035
Time 2	37.9 (2.6)	33.3 (2.7)	0.327	182.9 (43.5)	188.1 (47.9)	0.469
Time 3	42.8 (2.5)	39.8 (2.6)	0.788	189.4 (41.6)	108.9 (45.8)	0.101

Note: All data reported as Marginal Means (SE). Task performance and task discontinuation time analyses controlled for performance and pre-task negative mood. Mean length of abstinence for HED = 4.26, 18.77, and 32.12 days at Time 1, 2, and 3, respectively.