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An Experimental Test of Trauma-Relevant Cue Exposure and Desire for Alcohol among Adolescents

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of the requirements for the degree of
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By

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Abstract

A burgeoning literature suggests a linkage between adolescent traumatic event exposure and problematic alcohol use. Research conducted with adults indicates that exposure to trauma-relevant cues elicits a desire to drink; however, no work has examined this association among adolescents. The current study was designed to build upon and extend this line of work. Participants were 72 community-recruited adolescents ($M_{age} = 16.19$; 34.7% girls). Trauma-exposed ($n = 47$) and non-exposed ($n = 25$) youth were assigned to either a 3-minute experimental (voluntary hyperventilation) or control task (low-arousal picture viewing). Desire to drink was assessed (1) prior to task assignment, and (2) after task completion. An analysis of covariance was utilized to assess post-task desire to drink as a function of group (trauma; no trauma) and task (experimental; control) after accounting for variance associated with baseline desire, negative affect, and frequency of alcohol consumption. Contrary to hypotheses, results indicated no differences in the desire to drink as a function of group, task, or the interaction. Findings are discussed in terms of study design and future efforts to forward this line of work.

This dissertation is approved for recommendation
to the Graduate Council.

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Acknowledgments

Dedication

This project is dedicated to my dad, who paved the road, has always been there for me, and makes me proud to be Dr. Blumenthal.

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An Experimental Test of Trauma-Relevant Cue Exposure and Desire for Alcohol among Adolescents

Co-morbidity across mental disorders is common (Kessler, Chiu, Demler, & Walters, 2005; Mineka, Watson, & Clark, 1998), and the co-occurrence of anxiety and alcohol-related problems is receiving increasing recognition as researchers begin to understand how each condition exacerbates the other (e.g., Merikangas et al., 1998). One area that has received relatively little empirical attention, particularly among adolescents, is the association between traumatic event exposure and alcohol use. Although available work suggests these factors are linked (e.g., Giaconia, Reinherz, & Silverman, 1995), the mechanisms underlying this association have not been well-studied. This relative degree of neglect is unfortunate, as a sophisticated understanding of how these factors are associated will be critical to developing effective intervention programs aimed at reducing alcohol use among youth at risk by virtue of trauma exposure (Gotfredson & Wilson, 2003; Mrazek & Haggerty, 1994; National Advisory Mental Health Council Workgroup on Mental Disorders Prevention Research, 1998). Drawing from adult work (Coffey et al., 2002; Salidan et al., 2003), available evidence suggests that exposure to trauma-relevant cues elicits an elevated desire to drink, although this association has not been directly tested among adolescents. An exemplar trauma-relevant cue is bodily arousal, which: (1) is commonly elicited during a traumatic event (Bryant & Panasetis, 2001; Nixon & Bryant, 2003), (2) can trigger heightened anxiety among traumatic event exposed adolescents (Hawks, Blumenthal, Feldner, Leen-Feldner, & Jones, 2011), and (3) elicits trauma-related memories (e.g., Wald & Taylor, 2008) as well as elevated desire for alcohol (Mulligan & McKay, 2001) among adults. However, our understanding of the theoretical linkage between exposure to trauma-cues and drinking urges among trauma exposed adolescents is in its relative infancy, and no study

has utilized "real-time" laboratory procedures to study the issue. Therefore, the current study sought to build upon and uniquely extend this line of work by evaluating whether the trauma-relevant cue of bodily arousal, elicited using a biological challenge, results in an elevated desire to drink among trauma exposed adolescents.

Traumatic Event Exposure among Adolescents: Description and Frequency of Co-occurring Alcohol Use

A traumatic event is an event during which an individual perceives threat to one's self or others, and experiences significant fear, helplessness, or horror in response [American Psychiatric Association (APA), 2000]. Traumatic event exposure is common among adolescents (e.g., Giaconia et al., 1994) with a recent large-scale study suggesting 68% of youth in the general community had been exposed to a trauma by age 16 years (Copeland, Keeler, Angold, & Costello, 2007). The rates are even higher among certain at-risk populations, including adolescents seeking substance use treatment (87%; Jaycox, Ebener, & Damesek, 2004). Traumatic event exposure has been linked to an array of subsequent psychopathology, including posttraumatic stress disorder (PTSD; Yehuda, Halligan, & Grossman, 2001), panic attacks (Nixon, Resick, & Griffen, 2004), and depression (Lipschitz, Rasmusson, Anyan, Cromwell, & Southwick, 2000). Further, adolescent trauma exposure is associated with an increased risk for the development of substance use (see Blumenthal et al., 2008 for a review), and alcohol use in particular (Clark, Lesnick, & Hegedus, 1997). For example, in a community-based sample of 384 adolescents, Giaconia and colleagues (1995) found that trauma exposed youth were at twice the risk for alcohol dependence than were those who had never experienced a trauma. Other work has found trauma exposed adolescents evidence a four-fold increase in the risk for an alcohol use disorder (AUD) compared to non-exposed youth (Boyd-Ball, Mason, & Noonan, 2006). In terms of the

directionality of effects, a small but growing body of work suggests that trauma exposure often precedes alcohol use and related problems (Blumenthal et al., 2008; Stewart, 1996). For example, Clark and colleagues (1997) found that among adolescents presenting with co-occurring trauma-AUD, the traumatic event occurred prior to the AUD in 76% of cases. Further, Wu and colleagues (2006) found that among high school students, direct exposure to the September 11th 2001 World Trade Center attacks significantly predicted increased alcohol use in the following year, even after accounting for the effects of other related variables (e.g., age). Finally, Stein and colleagues (2002) found that the presence of an AUD among youth (ages 14-24 years) did not predict trauma exposure across a four-year follow-up period, although the authors did not investigate whether trauma exposure predicted subsequent alcohol use. Overall, these findings among youth are consistent with the large body of adult work supportive of a linkage between trauma exposure and problematic alcohol use (see Stewart, 1996 for a review). A key next step in this literature relates to better understanding the nature of the trauma-alcohol association among adolescents.

Underage Alcohol Use: Description and Clinical Significance

Adolescent alcohol use is a critical public health concern, with linkages to an array of negative consequences, including poor academic performance, risky sexual behavior, increased delinquency (e.g., vandalism; Hingson & Kenkel, 2004), as well as an increased risk of unintentional (e.g., traffic accidents; National Highway Traffic Safety Administration, 2002) and intentional (e.g., suicide; Levy, Miller, & Lox, 1999) death. Conservative estimates place the cost of underage alcohol use in the United States at a minimum of $62 billion annually, including $35 billion related to violent crime and $10 billion to traffic accidents alone (Pacific Institute for Research & Evaluation, 2011). Further, although adolescent alcohol use often reflects normative

experimentation related to this period of development, the use of alcohol during adolescence is nonetheless positively correlated with problematic alcohol use in adulthood (Rohde, Lewinsohn, Kahler, Seeley, & Brown, 2001; Wittchen et al., 2008), and adolescents have been found to progress more rapidly from initial use to substance-related problems as compared to adults (Deas, Riggs, Langenbucher, Goldman, & Brown, 2000). Despite concerted efforts aimed at reducing adolescent alcohol use (Stewart et al., 2005), rates of use among youth remain alarmingly high. For example, 72.5% of high school students report prior alcohol use, 41.8% report current use, and 24.2% endorse episodic heavy drinking [i.e., ≥ 5 drinks within a couple of hours at least once in the past 30 days; Centers for Disease Control and Prevention (CDC), 2010]. These data highlight the fact that we are not currently on track to meet the Healthy People 2020 Objective of 83.5% of youth refraining from any current substance use (including alcohol; U.S. Dept. of Health and Human Services, 2011).

Importantly, research suggests that one population of at-risk youth are those who have experienced a traumatic event, as these youth not only evidence increases in alcohol use following trauma exposure (e.g., Wu et al., 2006), but also evidence elevated levels of hazardous use behaviors (e.g., Giaconia et al., 1995), such as heavy drinking, a pattern of use that has been associated with an increased risk for alcohol-related problems (Jackson, 2008). Indeed, alcohol use among adolescents is often accompanied by a variety of problem behaviors, including failure to complete high school, reduced engagement in prosocial activities (e.g., clubs; substance-free activities), limited bonding with parents, and additional illicit substance use (Hill, White, Chung, Hawkins, & Catalano, 2000). Given that alcohol use often begins in adolescence (Newes-Adeyi, Chiung, Williams, & Faden, 2005), coupled with the fact that a substantial minority of youth, particularly those who have experienced a trauma (e.g., Giaconia et al., 1995) will often engage in

risky patterns of use (e.g., heavy drinking; Deas et al., 2000), it is critical that we obtain a better understanding of the processes that underlie alcohol use within these high-risk samples of youth.

Exposure to Bodily Arousal as a Risk Factor for Alcohol Use among Trauma-Exposed Adolescents

Bodily arousal represents a promising trauma-relevant stimulus with conceptual relevance to understanding the trauma-alcohol linkage among adolescents for at least three key reasons. First, bodily arousal (e.g., racing heart; sweating) is a prototypic feature of trauma exposure (e.g., Nixon & Bryant, 2003) and is theorized to play a role in peri-traumatic fear conditioning central to problematic recovery following traumatic events (Bryant, 2003; Shalev et al., 1998). Indeed, elevated bodily arousal has been shown to trigger heightened anxiety among both trauma exposed adolescents (Hawks et al., 2011) and adults (Wald & Taylor, 2007; 2008). For instance, Hawks and colleagues examined anxious responding to bodily arousal elicited by a voluntary hyperventilation challenge among adolescents (aged 10-17 years) who reported a positive ($n =$ 39) or negative ($n = 88$) history of traumatic event exposure as defined by the *Diagnostic and Statistical Manual of Mental Disorders, Fourth edition Text Revision* (DSM-IV-TR; APA, 2000). Importantly, compared to non-exposed youth, youth who had experienced a traumatic event evidenced significantly elevated post-challenge anxiety even after accounting for significant variance associated with negative affectivity and baseline anxiety. Other work conducted with adults suggests that elevated bodily arousal not only elicits heightened anxiety but also trauma-related memories (Wald & Taylor, 2007; 2008).

Second, naturalistic evidence indicates that trauma exposed adults consume excessive amounts of alcohol in the presence of bodily arousal (Sharkansky, Brief, Peirce, Meehan, & Mannix, 1999; Stewart, Conrad, Samoluk, Pihl, & Dongier, 2000). For example, in a sample of

294 substance abusing women exposed to a variety of traumas, Stewart and colleagues (2000) found that physiological arousal was positively associated with alcohol use. Similar findings were observed in a sample of male veterans (Sharkansky et al., 1999), suggesting bodily arousal represents an important cue that elicits alcohol use among trauma exposed adults, although the relevant literature base has relied exclusively on self-report. Importantly, laboratory-based work conducted with adults indicates that exposure to trauma-relevant cues via a script-driven imagery protocol (Pitman et al., 1987) increases craving for alcohol among trauma exposed individuals (Coffey et al., 2002; Coffey, Staiewicz, Hughes, & Brimo, 2006; Saladin et al., 2003). For example, among 45 adults presenting with comorbid alcohol dependence-PTSD, Coffey and colleagues (2002) reported that urges to consume alcohol were comparable across conditions in which participants were presented with an ideographic trauma script or an in vivo exposure to their preferred beverage (e.g., Jack Daniels whiskey), and that both conditions produced elevated urges to consume as compared to a neutral script or a non-alcoholic beverage.

Together, this growing body of work suggests that bodily arousal represents a trauma-relevant cue that can be easily and safely elicited among adolescents (Hawks et al., 2011; Leen-Feldner, Feldner, Bernstein, McCormick, & Zvolensky, 2005; Unnewehr, Schneider, Margraf, Jenkins, & Florin, 1996), and will uniquely extend extant work with adults suggesting that trauma-cue exposure elicits the desire to drink (e.g., Coffey et al., 2002).

Finally, such work needs to be extended to adolescents because adolescence represents a critical developmental epoch during which somatic perturbation may play a particular role in enhancing anxiety symptomatology (Reardon, Leen-Feldner, & Hayward, 2009). More specifically, bodily arousal is a frequent occurrence among adolescents because puberty, the hallmark feature of this period (Hayward & Sanborn, 2002), is characterized by profound

somatic events (Rogol, Roemmich, & Clark, 2002; Sheehy, Gasser, Molinari, & Largo, 1999), including abrupt increases in bodily arousal (Buchanan, Eccles, & Becker, 1992). Thus, understanding the linkages between bodily arousal and alcohol use among trauma-exposed youth *in particular* represents a unique and timely extension to the extant literature. Collectively, there is a theoretical and empirical basis for expecting that exposure to bodily arousal might be associated with the desire to drink among trauma exposed adolescents, although this hypothesis has never been directly tested.

Integrative Summary and Current Study

One factor that appears to place adolescents at risk for problematic alcohol use is traumatic event exposure (Giaconia et al., 1995), although the mechanisms underlying this association have not been well-studied. This relative degree of neglect is unfortunate, as such efforts are critical to the development of effective intervention programs aimed at reducing alcohol use among trauma exposed youth (e.g., Gotfredson & Wilson, 2003; Mrazek & Haggerty, 1994). Drawing from the adult literature, available evidence suggests that exposure to trauma-relevant cues elicits an elevated urge to drink (e.g., Salidan et al., 2003), and that bodily arousal may represent a specific trauma-cue that is associated with increased drinking urges (e.g., Stewart et al., 2000). The extant literature is characterized by at least four challenges, including 1) the relatively small size of the research base, 2) the absence of experimental work to address cause-and-effect relations, 3) no utilization of "real-time" biological challenge procedures designed to limit the impact of affective and recall biases, and 4) no work with adolescents. The current study therefore seeks to build upon and uniquely extend the emerging literature by evaluating whether exposure to bodily arousal elicits an increased desire to drink among trauma exposed (versus non-exposed) adolescents. This extension to youth is critical as adolescents are at significant risk for exposure

to traumatic events (e.g., Copeland et al., 2007) as well as initiation and intensification of alcohol use (Kandal & Logan, 1984). Construction of developmentally-informed (Salmon & Bryant, 2002; van der Kolk, 2005) models of the trauma-alcohol comorbidity require the empirical evaluation of these factors among adolescents, as such processes identified in adults cannot be assumed to exist or function identically at other stages of development (Cicchetti & Rogosch, 2002; Rutter & Sroufe, 2000; Sameroff, 2000), particularly in terms of alcohol use outcomes and behaviors (Deas et al., 2000; Windle et al., 2008).

With this backdrop, the current study evaluated whether the trauma-relevant cue of bodily arousal resulted in an increased desire to drink among trauma-exposed, as compared to non-exposed, adolescents assigned to either a voluntary hyperventilation challenge or a low-arousal control condition. Specifically, a 2 (group: trauma exposure; no trauma exposure) x 2 (condition: voluntary hyperventilation; low-arousal control) between subjects design was utilized to examine the following hypotheses:

Preliminary Hypotheses (Manipulation check):

- A main effect of condition was expected such that expired carbon dioxide (pCO_2) would be significantly reduced during the hyperventilation challenge as compared to the control condition (i.e., task engagement; Rapee et al., 1992). Further, consistent with prior work (e.g., Hawks et al., 2011), this effect would not differ as a function of trauma history.

- A main effect of condition was expected such that heightened anxiety would be observed among adolescents following the hyperventilation challenge as compared to the control condition. Further, consistent with prior work (Hawks et al., 2011), anxiety elicited by the challenge would be greatest among trauma-exposed, as compared to

non-exposed, adolescents.

- Finally, consistent with prior work conducted with adults (e.g., Wald & Taylor, 2007; 2008), it was expected that only trauma-exposed youth completing the hyperventilation challenge would report trauma-relevant memories during the task.

Primary Hypothesis:

- Main effects of group and condition were expected to be qualified by a significant interaction wherein post-task desire to consume alcohol would be greatest among trauma-exposed youth following the voluntary hyperventilation challenge.

Power Analysis

Limited research has been conducted on the desire to drink following exposure to trauma-relevant cues, and there are no studies examining this relationship among adolescents. Drawing on adult work that has examined the desire to drink following a trauma-relevant script-driven imagery procedure (as compared to a neutral-script; Coffey et al., 2006), the data suggest a relatively robust relationship, and a moderate-large effect size of $d = .70$ (Wilcox, 2006). Accordingly, a conservative power analysis based on a medium effect size of $f = .30$ (with power of .80 and alpha at .05) was conducted, suggesting a required sample size of 90 participants. Thus, a sample of 96 participants was determined to ensure even distribution across groups.

Participants

A total of 96 adolescents (ages 12-17 years; 40.6% girls) who reported a positive history of recent (i.e., within the past 6 months; Cooper, Frone, Russell, & Mudar, 1995; Huselid & Cooper, 1992) alcohol use were recruited from the general community. Exclusionary criteria were as follows: 1) lifetime history of panic disorder (PD), PTSD, or AUD; 2) chronic cardiac (e.g., hypertension) or respiratory (e.g., asthma) problems related to physiological arousal; 3)

current pregnancy; 4) current suicidality; 5) limited mental capacity or inability to provide

informed, written assent to participate; or 6) absence of a parent or legal guardian to provide

written informed consent (for child participation) prior to participation. Following laboratory

screening procedures (described below), eight participants were excluded from challenge

assignment: four presented with possible PD, three possible PTSD, and one both PD and PTSD.

Finally, participants selected for analysis included only those who completed all primary

measures, resulting in a final sample of 72 adolescents (ages 12-17 years, M_{age} = 16.19, SD =

1.44; 34.7% girls).

The ethnic (Hispanic/Latino; not Hispanic/Latino) and racial composition of the final sample

was as follows: 8.3% Hispanic/Latino, 86% Caucasian, 4.2% African American, 1.4% Native

American, 1.4% Asian, 2.8% Bi/Multi-racial, and 4.2% "other." A median family income of

$65,000 ($M$ = $81,236.36, SD = $74, 315.87) was reported by parents who accompanied

participants to the laboratory (67.4% biological mothers). Parental education was as follows:

2.4% did not complete high school, 13% received a high school diploma or equivalent degree,

30.4% completed some college, 23% held Associate's or Bachelor's degrees, 6.5% reported

some graduate or professional schooling, and 13% completed graduate or professional school.

Approximately 73.3% of parents reported being married or living with someone, 20% separated

or divorced, and 6.7% never married.

Traumatic event exposure was reported by 65.3% (n = 47) of the final sample; of those,

approximately 40% (n = 19) experienced two or more different types of events. Types of events

reported by participants included severe illness or injury (n = 16), witnessing another person die

or get badly injured (n = 17), severe accident or fire (n = 9), natural disaster (e.g., tornado,

hurricane; *n* = 13), physical assault (*n* = 10), sexual assault (*n* = 13), and three "other" (i.e., near drowning).

Measures

Screening assessment. As noted above, inclusionary, exclusionary, and grouping criteria include psychological, medical, and alcohol use history; the assessment of each of these criteria is detailed below.

Traumatic event history and psychological exclusionary criteria. The ADIS-C (Silverman & Albano, 1996) was administered to establish the presence of DSM-IV-TR-defined trauma exposure (APA, 2000), as well as additional psychological exclusionary criteria (i.e., PD, PTSD, AUD, current suicidality). For example, the traumatic event assessment includes the listing of eight specific events (e.g., "Has anyone ever robbed or attacked you?", "Has anyone touched you on parts of your body that you really did not want them to touch?), as well as any other upsetting events not explicitly listed in the interview. Affirmative responses were then further probed to determine whether significant threat to self or others was perceived (i.e., DSM-IV Criterion A.1), as well as if a subjective reaction of intense fear, helplessness, or horror (e.g., "Were you very afraid?") was present during the event (DSM-IV Criterion A.2). Subjective response was quantified via a "Feelings Thermometer," ranging from 0 (none) to 8 (extreme) to which participants have been previously "calibrated" (i.e., via practice questions; a rating of 4 or more indicates significant emotional response; Silverman, Saavedra, & Pina, 2001). The ADIS-C is a well-established semi-structured interview that evidences excellent psychometric properties, including inter-rater (e.g., $\kappa = .91$; Lyneham, Abbott, & Rapee, 2007) and test-retest (e.g., at 7-14 days, $\kappa = .63-.80$ for diagnostic status; Silverman et al., 2001) reliability, as well as convergent and discriminant validity (Wood, Piacentini, Bergman, McCracken, & Barrios, 2002).

Medically-based exclusionary criteria. Consistent with prior biological challenge work conducted with adolescents, lifetime history of relevant medical conditions was assessed via a structured medical health interview (e.g., Leen-Feldner, Reardon, & Zvolensky, 2007). The interview consists of a series of two-part open-ended questions, asking (1) whether a doctor has ever diagnosed the participant with a specific condition (e.g., asthma), and (2) whether the participant has any reason to believe that they might have the condition. Medical conditions that resulted in exclusion from the study were (1) chronic cardiac (e.g., hypertension) or (2) respiratory (e.g., bronchitis) conditions related to physical activity, and (3) possible pregnancy. The full interview was administered separately to the parent (regarding child medical history) and adolescent immediately following informed consent/assent in the laboratory.

History of alcohol consumption. Relevant items from the well-established Youth Risk Behavior Survey (CDC, 2006) in conjunction with a timeline follow-back procedure (Chung, Maisto, Cornelius, & Martin, 2004; Sobell & Sobell, 1996; Winters, 2003) were used to screen for recent alcohol use. Only youth endorsing a positive history of alcohol consumption (i.e., at least one standard drink: 5 oz. of wine, 12 oz. beer, 1.5 oz. spirits; National Institute on Alcohol and Alcoholism, 2000) in the past six months were eligible to participate in the current study (e.g., Cooper et al., 1995). Specifically, screening procedures included the YRBS-drawn questions: "[Other than for religious purposes], have you ever had an alcoholic drink?" and "Over the past month (30 days), [on any day] did you have a drink of alcohol?" A timeline follow-back procedure (e.g., Chung et al., 2004) was then used to assess for alcohol consumption over the past six months. Specifically, adolescents were progressively asked about alcohol consumption across this period (e.g., participation occurs in December; the next month addressed is November, then October, etc.). Telephone screening included a single question, "As best you

can remember, did you have at least one full alcoholic beverage during that month" to which

participants responded either yes or no to each month listed. Assessment in the laboratory

included the use of standard (e.g., holidays) and personal (e.g., birthdays) events as anchors

within each month, and a two-part question: "During [this month] on how many days did you

consume alcohol," and "On [each occasion], how much did you consume?" A printed calendar

was used to aid in establishing anchors and consumption behaviors for each month. Importantly,

these procedures have been successfully used to establish alcohol consumption behaviors among

adolescents in prior work (e.g., Waldron, Slesnick, Brody, Turner, & Peterson, 2001; Winters,

2003).

Baseline characteristics. In addition to baseline desire for alcohol, a number of

theoretically-relevant variables (detailed below) also were assessed in an effort to address the

specificity of the proposed associations.

Desire for alcohol. Participants' desire to consume alcohol was determined using the well-

established Desires for Alcohol Questionnaire (DAQ; Love, James, & Willner, 1998). The DAQ

includes 28 items to which participants indicate their agreement with how much each statement

reflects how they currently feel on a scale of 1 (strongly disagree) to 7 (strongly agree). Items

reflect moderate (e.g., "I might like a drink now"), as well as strong (e.g., "I need a drink now")

desires for alcohol; responses are summed to reflect an overall desire for alcohol score. The

DAQ evidences excellent psychometric properties [e.g., distinguishing between excessive (i.e.,

frequency), binge (i.e., amount), and moderate/non-binge drinkers; internal consistency (e.g.,

Cronbach's α = .97 in the current sample); Love et al., 1998], and has been successfully

employed in studies examining social drinkers (Duka, Jackson, Smith, Stephens, 1999; Schulze

& Jones, 2000), alcohol dependent (Tapert, Brown, Baratta, & Brown, 2004), as well as

adolescent populations (Tapert et al., 2003).

Other theoretically relevant variables. Chronological age, frequency of alcohol consumption (e.g., Maddahian, Newcomb, & Bentler, 1988), negative affect (e.g., Colder & Chassin, 1993), anxiety sensitivity (see Kuntsche, Knibbe, Gmel, & Engles, 2006), nicotine use (e.g., Jackson, Sher, Cooper, & Wood, 2002), and parental AUD history (e.g., Stice, Barrera, & Chassin, 1998) were examined as potential covariates in all analyses.

Alcohol use frequency. Alcohol use frequency was indexed using the Adolescent Alcohol and Drug Involvement Scale (AADIS; Moberg, 2000), an adaptation of the well-established Adolescent Drug Involvement Scale (Moberg & Hahn, 1991). This face-valid measure asks participants to rate on a visually presented scale of 0 (never used) to 7 (several times a day) how often they drink alcohol. Higher numbers reflect increased alcohol consumption, and each response point is accompanied by a written descriptor (e.g., 2 = *several times a year*; 3 = *several times a month*; 4 = *weekends*). Importantly, this scale has been successfully used in prior work examining similar community-based (e.g., Blumenthal, Leen-Feldner, Frala, Badour, & Ham, 2010) as well as traumatic event-exposed (Dixon, Leen-Feldner, Ham, Feldner, & Lewis, 2009) samples of adolescents.

Negative affect. The generalized proclivity to experience negative affectivity (NA) was measured using the NA subscale of the Positive and Negative Affect Schedule for Children (PANAS-C; Joiner, Catanzaro, & Laurent, 1996; Wilson, Gullone, & Moss, 1998). Participants rate 15 descriptors (e.g., upset, nervous, sad) on a five-point Likert-type scale (1 = *very slightly* to 5 = *extremely*), indicating how they have been feeling over the past few weeks; responses are summed to provide a total NA score. This instrument has demonstrated adequate psychometric properties, including good internal consistency (Joiner, 1999; Joiner et al., 1996, 2002; α = .89 in

the current sample) as well as convergent and discriminant validity (Joiner et al., 1996, 2002), and has been successfully utilized in research conducted with traumatic-event exposed youth (Hawks et al., 2011; Weems et al., 2007).

Anxiety sensitivity. Anxiety sensitivity (AS) was assessed via the 18-item Child Anxiety Sensitivity Index (CASI; Silverman, Fleisig, Rabian, & Peterson, 1991) on which participants rate the degree to which they experience fear in response to symptoms of anxiety. Specifically, participants rate statements reflecting the aversive nature of anxiety symptoms (e.g., "It scares me when I have trouble getting my breath;" "It scares me when I feel 'shaky'") on a three point scale (1 = *none*, 2 = *some*, 3 = *a lot*); ratings are then summed to provide a total AS score. The CASI was validated with adolescents, has good internal consistency (e.g., α = .85 in the current sample) and test-retest reliability (e.g., r = .76 at two weeks), and is significantly correlated with other anxiety-relevant measures (Silverman et al., 1991).

Smoking history. Cigarette use was evaluated using the widely used National Cancer Institute's Smoking History Questionnaire (SHQ). A continuous assessment of recent smoking history was employed in the current study. Specifically, participants responded to the following question: "During the past month (30 days), how many cigarettes did you smoke in an average day?" This measure has been successfully employed in prior research with adolescents (e.g., Dino et al., 2001; Horn et al., 1999).

Parental AUD. The presence of lifetime parental AUD (i.e., abuse, dependence) was measured using the Structured Clinical Interview for DSM-IV (SCID-I; First et al., 2002). Interview questions are presented alongside operational definitions of each symptom, and responses are coded as absent, subclinical, or clinically present for each DSM-IV-defined symptom. Identification of at least one clinically present symptom of alcohol abuse, or three

clinically present symptoms of alcohol dependence indicate the presence of an AUD (APA, 2000; First et al., 2002). The alcohol use subscale of this instrument has demonstrated excellent psychometric properties, including test-retest ($\kappa = .77$ at 7-10 days) and inter-rater reliability ($\kappa = 1.0$; Zanarini, 2000), as well as concurrent, discriminant, and predictive validity (Kranzler, Kadden, Burleson, & Babor, 1995; Kranzler, Kadden, Babor, & Tennen, 1996). As approximately one-third of parents ($n = 24$) chose not to participate, three categories were employed in the current study: AUD negative (AUD-), AUD positive (AUD+), and not assessed (na).

Laboratory-based challenge indices. Participants endorsing a positive or negative history of DSM-defined traumatic event(s) were assigned to either a voluntary hyperventilation challenge or a low-arousal control condition. Expired carbon dioxide was monitored continuously throughout the experimental task; current level of anxiety was assessed at baseline and following task completion; post-challenge DAQ ratings were assessed (items randomly ordered to limit order effects); and the presence of trauma-related memories were probed prior to formal debriefing.

Voluntary hyperventilation. Voluntary hyperventilation served as the challenge procedure because it has been safely administered to adolescents in the past (e.g., Unnewehr et al., 1996), including by our team (e.g., Blumenthal et al., in press; Hawks et al., 2011; Leen-Feldner et al., 2005; 2007). The challenge interval involved a 3-min hyperventilation with a breathing rate of 30 respiratory cycles/min, a rate shown to produce significant bodily arousal (e.g., increased heart rate, sweating, tingling; Fried & Grimaldi, 1993). Audiotaped directions guided participants through the hyperventilation procedure to ensure standardization. Specifically, following the baseline period, participants listened to the following instructions:

"Now we will begin the breathing exercise. In this exercise, you will be asked to breathe

in and breathe out very deeply. The instructions will tell you when you should breathe in

and when you should breathe out. Simply inhale when asked to "breathe in," and exhale

when asked to "breathe out" – making each breath in as deep as possible and each breath

out as forceful as possible. It is important that you follow these instructions as best as you

can, and continue the exercise until you are asked to stop and rest."

Although bodily arousal elicited by voluntary hyperventilation is typically less intense than

some procedures (e.g., CO_2 administration), evidence suggests it nonetheless effectively elicits

somatic perturbation (Antony Ledley, Liss, & Swinson, 2006; Holt & Andrews, 1989;

Spinhoven, Onstein, Sterk, & Le Haen-Versteijnen, 1992), as well as elevated anxiety among

trauma exposed adolescents as compared to non-exposed youth (Hawks et al., 2011).

Low-arousal control. Participants in the control condition engaged in all aspects of the

procedure (e.g., pCO_2 monitoring; anxiety ratings) *except* the hyperventilation challenge itself;

participants in this condition instead viewed a three-minute loop of neutral images (e.g., spoon;

chair) from the International Affective Picture System (IAPS; Center for the Study of Emotion

and Attention, 1995). Specifically, a set of 12 neutral pictures were presented 3 times each: each

of the pictures remained on the computer screen for 5 seconds (Lang, Bradley, & Cuthbert, 1997;

2008) and each picture was presented in random order within each set. These slides have been

successfully used in the past to elicit neutral affective states and minimal physiological arousal

among adolescents (e.g., Leen-Feldner, Zvolensky, & Feldner 2004; McManis, Bradley, Berg,

Cuthbert, & Lang, 2001; Lang et al., 2008).

Manipulation check: Expired carbon dioxide. Participants were fitted with a continuous

positive pressure C-Pap Mask and expired levels of carbon dioxide (pCO_2) were monitored via a

Novametrix CO_2/SMO Capnograph. For the current study, baseline (i.e., immediately pre-task) and task-low (i.e., lowest level recorded during the task) were recorded. These data were utilized to evaluate the degree to which participants engaged in the hyperventilation challenge (e.g., Rapee et al., 1992).

Manipulation check: Self-reported anxiety. Self-reported anxiety was indexed using a Subjective Units of Distress Scale (SUDS; Perrin, Smith, & Yule, 2000; Wolpe, 1958). Specifically, participants rated current anxiety levels on a visually presented scale of 0 (*no anxiety*) to 10 (*extreme anxiety*) at baseline, immediately following the experimental task, and every 60 seconds during the ten minute recovery period. Recorded and utilized data were coded on a scale of 1 to 11 (e.g., see **General Analytic Strategy**). These data were used to evaluate the degree to which the challenge was effective in eliciting anxious arousal. This is a well-established procedure for the assessment of self-reported anxious responding among adolescents (e.g., Gotlib, Traill, Montoya, Joormann, & Chang, 2005; Perrin, Smith, & Yule, 2000; Pine et al., 2000).

Manipulation check: Trauma-related memories. To evaluate whether the voluntary hyperventilation challenge elicited trauma-related memories, participants responded to two open-ended questions following the recovery period. Specifically, after removing the C-Pap mask, the experimenter asked the following questions: (1) Did you think about anything in particular during the task, and (2) Did you think about anything that we talked about during the interview? Responses were recorded both quantitatively (i.e., 0 = not Trauma-related; 1 = Trauma-related) and qualitatively (i.e., actual participant response). The indirect, open-ended format was chosen such that questions would be relevant to all participants (e.g., no trauma group) and in an effort to preclude potential response biases.

Procedure

All study procedures were approved by the U of A Institutional Review Board prior to participant contact. Adolescents and parents responding to recruitment efforts were given a detailed description of the study procedures. Following verbal consent from the parent or legal guardian, interested youth were screened for (1) chronic respiratory conditions related to physical exertion, and (2) recent alcohol consumption. Adolescents eligible at this stage were invited to the laboratory (accompanied by a parent or legal guardian). At this session, written parental consent (for child participation) and adolescent assent were obtained, and a standard mental health referral sheet was provided to all participants and their parents. Consent and assent materials described the study, including a detailed description of the voluntary hyperventilation procedure and the potential effects of the challenge (e.g., racing heart). Parents also read and signed a second consent form detailing their participation in the study (i.e., brief clinical interview), as well as the potential risks and benefits associated with this procedure. Upon provision of informed consent/assent, the medical history questionnaire was administered privately to each the parent (regarding child history) and adolescent, and the alcohol use assessment (e.g., timeline follow-back) was again administered and recorded. Adolescent participants then completed the first battery of questionnaires, including the baseline DAQ, AADIS, PANAS, CASI, and SHQ. During this time, parents interested in participating completed the alcohol use portion of the SCID-I interview as well as a brief questionnaire packet which included demographic information. Participating parents were then thanked and compensated $5.

Once the initial questionnaire battery was completed, the ADIS-C was administered, and eligible participants were assigned to the task (i.e., hyperventilation or IAPS). Participants were

outfitted with physiological monitoring equipment, including the C-Pap mask, and task procedures were explained. The procedure was comprised of three stages: 1) 5 minute baseline; 2) 3 minute hyperventilation challenge/low-arousal activity; and 3) 10 minute recovery. Immediately following completion of the task, participants provided ratings of current desire to drink (i.e., the DAQ; items randomly re-ordered to limit sequence effects) along with current anxiety ratings. Following the 10-minute recovery period the monitoring equipment was removed, participants were asked about thoughts during the task (as described above), and re-united with the present parent for debriefing.

Consistent with published recommendations (Sieber, 1983; Tesch, 1977), debriefing focused on the ethical, educational, methodological, and participant satisfaction function of participant debriefing. Information was tailored to the comprehension level of the adolescent, and references were made to "stressful events" and "health-related behaviors" (e.g., alcohol use) to protect participant confidentiality. Participants were educated about potential risk following traumatic event exposure as indicated by work conducted with adults, and the current study's primary aim of examining such relations among youth. The group (i.e., trauma, no-trauma) and experimental (i.e., hyperventilation, IAPS) structure of the current study was described, as was the purpose of both experimental procedures (e.g., increasing bodily arousal), the recovery period (i.e., returning to a baseline state), and additional questionnaires and interviews (i.e., covariates, baseline state). Finally, participants were informed as to the potential public health significance of understanding the role of trauma in "health-related behaviors" among adolescents, and the role of the current study in forwarding this body of work. After answering any questions the parent and/or participant had, both parties were thanked and all adolescents (i.e., including those who did not complete the task) were compensated $40.

General Analytic Strategy

Preliminary analyses were conducted with raw data. Indicated variables evidencing a positive (i.e., NA, baseline anxiety, baseline and post DAQ) or negative skew (i.e., age, baseline pCO_2) were logarithmic or square transformed, respectively, for use in the analyses of covariance.

Preliminary analyses. Sample descriptives, relations with the primary outcome variable (i.e., desire to consume alcohol), and the equivalence of groups with regard to baseline characteristics (i.e., frequency of alcohol use, NA, AS, smoking history, and parental AUD) were assessed. Zero-order correlations were computed between continuous variables (e.g., NA); chi-square analyses, t-tests, and analyses of variance (ANOVAs) were used to assess for differences in terms of group-based variables (e.g., parental AUD). Baseline characteristics significantly related to the primary outcome variable, and those that differed across groups, were used as covariates in subsequent analyses.

Analyses of covariance [ANCOVAs] were used to confirm participant engagement (i.e., pCO_2 levels) as well as the efficacy of the hyperventilation procedure in increasing self-reported anxiety. Specifically, task-low pCO_2 and post-challenge anxiety ratings (respectively) were entered as the dependent variable, group (trauma exposure; no trauma exposure) and condition (voluntary hyperventilation; control) were entered as fixed factors, and baseline pCO_2/anxiety (respectively) and NA (please see **Preliminary Analyses** below) were entered as covariates. As chronological age also was significantly related to post-challenge anxiety, this variable was included as a covariate in the respective analysis. Effect size was indexed via partial eta squared (η_p^2). Finally, frequency and type of participant thoughts during the task are reported.

Primary analysis. An ANCOVA was utilized to test the primary hypothesis. Specifically, after including baseline DAQ totals and indicated covariates (please see **Preliminary Analyses**

below), post-task DAQ totals were entered as the dependent variable, and group (trauma exposure; no trauma exposure) and condition (voluntary hyperventilation; control) were entered as fixed factors. Effect size was indexed via partial eta squared (η_p^2).

Results

Preliminary Analyses

The hyperventilation task was completed by 53.2% of the trauma exposed participants and 60% of the non-exposed participants. Across all participants, days since most recent alcohol use ranged from 1 to 180 ($M = 32.26$, $SD = 35.93$), and did not differ as a function of traumatic event history [$t(70) = -0.74$, $p = .45$] or task assignment [$t(70) = 0.94$, $p = .35$]. Among trauma exposed youth, PTSD symptom totals ranged from 0 to 11 ($M = 4.04$, $SD = 3.24$; total possible = 18) and did not differ across conditions [$t(45) = 0.63$, $p = .53$]. Finally, lifetime history of an AUD was evidenced by 26.4% of all parents; 33.3% of parents did not participate in the interview. Please see Table 1 for additional descriptive data as a function of traumatic event history and task assignment, and Table 2 for zero-order correlations between all continuous predictor and outcome variables.

Relations with post-task DAQ. As seen in Table 2, baseline DAQ totals and frequency of alcohol consumption, as indexed via the AADIS, were positively associated with the post-challenge desire to drink among both trauma exposed ($r = .88$, $p < .001$; $r = .52$, $p < .001$, respectively) and non-exposed ($r = .95$, $p < .001$; $r = .45$, $p = .022$, respectively) adolescents; relations with all other potential continuous covariates did not meet traditional levels of significance (i.e., $p < .05$). Post-task DAQ totals also did not significantly differ as a function of gender [$M_{male} = 47.80$, $SD = 38.01$, $M_{female} = 65.08$, $SD = 36.53$; $t(70) = 1.88$, $p = .064$] or parental AUD status [$M_{AUD-} = 58.13$, $SD = 35.58$, $M_{AUD+} = 69.63$, $SD = 45.81$, $M_{na} = 51.87$, SD

= 32.55; $F(2, 69) = 1.19$, $p = .308$]. Finally, post-task DAQ totals did not significantly differ as a function of task assignment [$M_{hyper} = 63.37$, $SD = 43.65$, $M_{control} = 53.71$, $SD = 28.37$; $t(70) = -1.08$, $p = .283$] or trauma history [$M_{trauma} = 57.55$, $SD = 36.53$, $M_{no-trauma} = 61.96$, $SD = 40.44$; $t(70) = 0.46$, $p = .640$].

Baseline group differences: Trauma history. Preliminary analyses indicated that groups were matched across all selected variables. Specifically, groups did not significantly differ as a function of gender [$\chi^2(1, n = 72) = 1.94$, $p = .163$], parental AUD status [$\chi^2(2, n = 72) = 1.10$, $p = .579$], chronological age [$t(70) = 0.58$, $p = .559$], frequency of alcohol use [$t(70) = -1.91$, $p = .060$], NA [$t(70) = -0.56$, $p = .571$], AS [$t(70) = -1.97$, $p = .053$], or recent smoking history [$t(70) = -1.22$, $p = .225$].

Baseline group differences: Experimental task. Preliminary analyses indicated that youth assigned to the hyperventilation challenge evidenced significantly higher NA ($M = 32.05$, $SD = 11.97$) as compared to those assigned to the control condition [$M = 26.65$, $SD = 8.82$; $t(70) = -2.12$, $p = .037$]; groups were matched across all other selected variables. Specifically, groups did not significantly differ as a function of gender [$\chi^2 (1, n = 72) = 1.10$, $p = .293$], parental AUD status [$\chi^2 (2, n = 72) = 1.88$, $p = .389$], chronological age [$t(70) = -0.86$, $p = .388$], frequency of alcohol use [$t(70) = -0.27$, $p = .781$], AS [$t(70) = -1.70$, $p = .094$], or recent smoking history [$t(70) = -1.19$, $p = .237$].

Manipulation check: pCO_2. As can be seen in Table 2, baseline pCO_2 levels were positively associated with task-low pCO_2 levels among both trauma exposed ($r = .47$, $p < .001$) and non-exposed ($r = .63$, $p < .001$) adolescents; relations with all other potential continuous covariates did not meet traditional levels of significance (i.e., $p < .05$). Task-low pCO_2 levels also did not significantly differ as a function of gender [$M_{male} = 25.09$, $SD = 11.94$, $M_{female} = 23.25$, $SD =$

10.93; $t(65) = 0.62$, $p = .535$], parental AUD status [$M_{AUD-} = 24.81$, $SD = 11.85$, $M_{AUD+} = 26.00$,

$SD = 12.52$, $M_{na} = 22.82$, $SD = 10.70$; $F(2, 64) = 0.38$, $p = .681$], or trauma history [$M_{trauma} =$

24.16, $SD = 12.79$, $M_{no-trauma} = 24.58$, $SD = 10.94$; $t(65) = -0.14$, $p = .889$]. Conversely, task-low

pCO_2 levels were significantly lower among youth participating in the hyperventilation challenge

($M = 16.20$, $SD = 5.75$) as compared to those in the control condition [$M = 36.62$, $SD = 5.46$;

$t(65) = 14.54$, $p < .001$].

Finally, an ANCOVA indicated that experimental group differences [$F(1, 61) = 313.77$, $p <$

.001, $\eta_p^2 = .83$]were robust to the inclusion of baseline pCO_2 levels [$F(1, 61) = 74.39$, $p < .001$,

$\eta_p^2 = .54$], and NA [$F(1, 61) = 2.20$, $p = .143$, $\eta_p^2 = .03$]. Further, as expected, neither traumatic

event history [$F(1, 61) = 0.07$, $p = .789$, $\eta_p^2 = .00$] nor the interaction [$F(1, 61) = 0.01$, $p = .978$,

$\eta_p^2 = .00$] were significant predictors of task-low pCO_2 levels.

Manipulation check: Self-reported anxiety. As can be seen in Table 2, chronological age

was positively associated with post-challenge anxiety among non-exposed adolescents ($r = .39$, p

$= .048$); relations with all other potential continuous covariates fell below traditional levels of

significance (i.e., $p < .05$). Post-challenge anxiety also did not significantly differ as a function of

gender [$M_{male} = 4.02$, $SD = 2.87$, $M_{female} = 3.88$, $SD = 2.75$; $t(70) = 0.20$, $p = .841$], parental AUD

status [$M_{AUD-} = 4.00$, $SD = 2.02$, $M_{AUD+} = 3.63$, $SD = 2.98$, $M_{na} = 4.20$, $SD = 2.76$; $F(2, 69) =$

0.21, $p = .803$], or trauma history [$M_{trauma} = 4.31$, $SD = 2.85$, $M_{no-trauma} = 3.22$, $SD = 2.68$; $t(70) =$

-1.44, $p = .153$]. Conversely, post-challenge anxiety was significantly higher among youth

participating in the hyperventilation challenge ($M = 4.65$, $SD = 3.00$) as compared to those in the

control condition [$M = 3.12$, $SD = 2.33$; $t(70) = -2.35$, $p = .021$].

Finally, an ANCOVA indicated that experimental group differences [$F(1, 65) = 8.53$, $p =$

.005, $\eta_p^2 = .11$] were robust to the inclusion of baseline anxiety [$F(1, 65) = 7.12$, $p = .010$, $\eta_p^2 =$

.09], chronological age [$F(1, 65) = 0.22$, $p = .641$, $\eta_p^2 = .00$], and NA [$F(1, 65) = 1.85$, $p = .177$, $\eta_p^2 = .02$]; however, neither traumatic event history [$F(1, 65) = 1.26$, $p = .265$, $\eta_p^2 = .01$] nor the interaction [$F(1, 65) = 0.37$, $p = .545$, $\eta_p^2 = .00$] were significant predictors of post-challenge anxiety.

Manipulation check: Trauma-related memories. In terms of the qualitative data, only two participants reported trauma-specific thoughts during the task; both were in the hyperventilation condition. Across both group and condition, the majority of participants reported thinking about "nothing in particular." Please see Table 3 for specific participant responses as a function of group and condition. Analysis of the quantitative data was not conducted given so few participants endorsed trauma-specific memories (i.e., $n = 2$).

Primary Analyses

As noted above, in addition to baseline DAQ totals preliminary analyses indicated the inclusion of NA and frequency of alcohol consumption as covariates in the final analysis. Prior to the inclusion of additional covariates, only baseline DAQ totals significantly predicted post-task DAQ totals, $F(1, 67) = 217.61$, $p < .001$, $\eta_p^2 = .76$; post-challenge totals were not significantly predicted by trauma history [$F(1, 67) = 0.84$, $p = .361$, $\eta_p^2 = .01$], group assignment [$F(1, 67) = 0.47$, $p = .828$, $\eta_p^2 = .00$], or the interaction [$F(1, 67) = 1.18$, $p = .280$, $\eta_p^2 = .01$]. Similarly, in the final model, only baseline DAQ totals [$F(1, 65) = 148.69$, $p < .001$, $\eta_p^2 = .69$] and NA [$F(1, 65) = 4.45$, $p = .039$, $\eta_p^2 = .06$] were significant predictors; post-challenge totals were not significantly predicted by frequency of alcohol use [$F(1, 65) = 0.29$, $p = .588$, $\eta_p^2 = .00$], trauma history [$F(1, 65) = 0.74$, $p = .392$, $\eta_p^2 = .01$], group assignment [$F(1, 65) = 0.45$, $p = .501$, $\eta_p^2 = .00$], or the interaction [$F(1, 65) = 1.09$, $p = .299$, $\eta_p^2 = .01$].

Discussion

Adolescent alcohol use is a critical public health concern with linkages to an array of negative consequences (e.g., Hingson & Kenkel, 2004; Levy et al., 1999). One factor that appears to place adolescents at risk for problematic consumption is traumatic event exposure (e.g., Giaconia et al., 1995). Drawing from the adult literature, available evidence suggests that exposure to trauma-relevant cues elicits an elevated urge to drink (e.g., Salidan et al., 2003), and that bodily arousal may represent a specific trauma-cue that is associated with increased drinking urges (e.g., Stewart et al., 2000); however, no work has examined this relation among youth. Accordingly, the current study utilized a 2 (group: trauma exposure; no trauma exposure) x 2 (condition: voluntary hyperventilation; low-arousal control) between subjects design to evaluate whether bodily arousal resulted in an increased desire to drink among trauma-exposed, as compared to non-exposed, adolescents. Consistent with hypotheses, preliminary analyses indicated that participants engaged in the experimental task (i.e., pCO_2 levels significantly reduced during the hyperventilation task as compared to the IAPS), and task engagement did not differ as a function of traumatic event history. Conversely, although the hyperventilation task increased anxiety, no differences in anxious reactivity were evidenced as a function of traumatic event history (cf. Hawks et al., 2011). Further, only trauma exposed youth who completed the hyperventilation challenge reported trauma-specific memories ($n = 2$), focus on somatic arousal ($n = 2$), or strong desire for physical/cognitive disengagement ($n = 2$; please see Table 3); however, the preponderance of responses were not specific, and taken together did not support the contention that somatic arousal elicits trauma-specific memories among youth. Finally, primary analyses indicated no differences in the desire to drink as a function of group, condition, or the interaction.

The largely non-significant findings of the current study suggest the following possible

conclusions: (1) exposure to trauma-relevant cues does not increase the desire to drink among adolescents, (2) bodily arousal is not an effective trauma-relevant cue in terms of increasing the desire to drink among adolescents, (3) the study findings are a function of sample-specific characteristics, and/or (4) the pattern of results is a function of the study design. Each of these considerations will be discussed, and design considerations are presented throughout the discussion.

First, contrary to work conducted with adults (Coffey et al., 2002, 2006; Saladin et al., 2003 Sharkansky et al., 1999; Stewart et al., 2000), the current study suggests that exposure to trauma-relevant cues is *not* related to an increased desire to consume alcohol among adolescents. This may be due, in part, to social and legal constraints limiting adolescents' access to alcohol, and thus opportunities to associate the consumption of alcohol with remittance of cue-related negative affectivity. Indeed, emerging evidence suggests that adolescents' beliefs about the effects of alcohol may be primarily informed by external sources (e.g., peers, media; Andrews & Hops, 2011; Snyder & Nordoff, 2011), and that both negative and positive expectancies related to changes in internal states (e.g., tension reduction) are less prominent among adolescents as compared to adults (Ham, Randall, Zamboanga, & Blumenthal, 2011). The combined effect of limited cue-consumption trials and externally-driven expectations may serve to protect trauma exposed youth from engaging in a pattern of alcohol consumption in response to trauma-specific cues. Specifically, adolescence may represent a "developmental window" during which coping-related drinking is being learned; given limited access to alcohol in the United States, this process is largely driven by observation and verbal transmission (e.g., via parents, peers), and the difficulty in acquiring alcohol when faced with a trauma-relevant cue may disrupt linking alcohol consumption and trauma-relevant negative affect reduction during this phase. Examining

this relation as a function of accessibility, as well as across countries with lower (e.g., 16; Germany) or no (e.g., Jamaica) legal drinking age would aid in determining the effect of external constraints on the development of drinking in response to trauma-relevant negative affectivity among youth. Further, future work addressing age-related differences via cross-sectional cohort or cross-sequential designs would provide support for differential responding as a function of developmental phase, and thus set the stage for more focused efforts examining the relative role of self-reported drinking behaviors as well as developmental considerations (e.g., cognitive development; Kuhn, & Franklin, 2006; Luna, Garver, Urban, Lazar, & Sweeney, 2004; Schell, Martino, Erickson, Collins, & McCaffrey, 2005) in relation to the trauma cue-alcohol use linkage. If future work supports the contention that trauma-relevant cue exposure increases the desire to drink (and/or actual alcohol consumption) among adults but not adolescents, intervention efforts targeting affective and behavioral responding to trauma cues among adolescents *before* they have learned to use alcohol in a coping-related fashion may help prevent the development of related alcohol use problems later in life.

An alternative interpretation of the current findings is that bodily arousal is not a specific or powerful enough trauma cue to induce the desire for alcohol among adolescents with a history of recent alcohol use. Consistent with this hypothesis, trauma exposed participants who completed the hyperventilation challenge generally did not report trauma-relevant memories during the task (cf. Wald & Taylor, 2008), nor was the difference in anxious responding (i.e., the trauma-by-task interaction) statistically significant (cf. Hawks et al., 2011). In terms of the former finding, limitations in the current study design must be considered. Specifically, the current study included an open-ended question regarding thoughts during the task following completion of both the task and recovery period. Although designed as a preliminary assessment in an effort to

reduce certain response biases (e.g., forced-choice, demand) as well as participant burden, this approach was susceptible to participant (a) memory distortions (e.g., report of activity throughout the baseline, task, and recovery periods rather than those specific to the experimental task), (b) effective cognitive avoidance/suppression during the task, and (c) fatigue (e.g., unwilling to discuss trauma further, proximity to study completion). Efforts designed to address the relation between bodily arousal and trauma-relevant responding among adolescents would benefit from the inclusion of more sophisticated assessments during and/or immediately following somatic perturbation. For example, laboratory-based work utilizing techniques such as the Stroop or lexical decision to examine trauma-relevant cognitions immediately following a bodily arousal induction (Meyer & Schvaneveldt, 1971; Pineles, Shipherd, Mostoufi, Abramovitz, & Yovel, 2009; Stroop, 1935) will provide important data regarding the (potential) linkage between somatic perturbation and trauma-relevant responding among adolescents.

In regard to the absence of an interaction effect in the current study, these findings stand in contrast to those reported by Hawks and colleagues (2011). Importantly, the current sample included only youth who reported recent alcohol consumption, and recent work from this laboratory suggests that alcohol use history positively predicts anxious responding to somatic arousal (Blumenthal, Leen-Feldner, Knapp, Bunaciu, & Zamboanga, in press[1]). Specifically, adolescents who reported continued use of alcohol, as compared to those who had never used as well as those who had tried but quit, evidenced relatively elevated fear of bodily arousal (i.e., typical responding as well as in response to a voluntary hyperventilation challenge). These data suggest that adolescents who report recent/regular alcohol use already may be at risk for fearful responding to bodily arousal, and thus the specificity of somatic perturbation as a trauma-relevant cue may be diluted in a sample of youth reporting recent alcohol consumption (also,

please see below in terms of sample considerations).

Future work designed to address the linkage between traumatic event exposure and alcohol use among youth would benefit from the inclusion of a more trauma-specific task, such as a script-driven imagery protocol (Pitman et al., 1987). For example, a within-subjects comparison of anxious responding and change in the desire to drink following presentation of neutral, ideographic non-trauma (e.g., sad, general stress), and trauma scripts would provide a direct assessment of the relation between trauma-cue exposure and the desire to drink among adolescents, and thus help clarify whether the current findings are indicative of responding to bodily arousal specifically, or trauma cues more generally.   It is notable that while a script-driven imagery procedure was considered as a possible affect induction procedure in the current study, this approach has never been validated for use with youth, making it a non-optimal "next step" in terms of forwarding this literature. The current study highlights the potential utility of validating such a procedure for use with youth.

Additional limitations in terms of the sampling strategy and composition also must be considered. First, in an effort to increase generalizability and feasibility, the number, type, and timing of traumatic event(s) experienced was not limited in the current study; youth who reported any DSM-IV-TR defined traumatic event were included in the trauma exposed group. However, a growing body of work suggests that the relative risk for problematic alcohol use among trauma exposed adolescents may vary as a function of traumatic event type, timing, and the number of experiences reported (e.g., Andersen & Teicher, 2009, Cisler et al., 2011). For example, using prospective data collected in the National Survey of Adolescents – Replication, Cisler and colleagues (2011) found that the number of potentially traumatic events experienced (as suggested for DSM-V definition) was positively related to frequency of binge drinking across

a three year period, and secondary analyses indicated that this relation were limited to assaultive (but not non-assaultive) events. These data suggest that the current sampling approach may have been too broad, and that techniques that allow for analyses powered to examine frequency and type of trauma exposure may address important nuances relevant to the theorized relation between cue exposure and alcohol use behaviors. For example, a series of studies designed to examine this relation as a function of trauma type (e.g., assaultive versus non-assaultive; sexual assault versus physical assault) as well as frequency (e.g., multiple event types, cumulative assaults) may aid in identifying specific subgroups of trauma exposed youth at risk for problematic consumption and thus inform targeted intervention efforts focused on alcohol use behaviors and/or prevention of repeated exposure.

The current sample also was comprised of a largely Caucasian, older, mixed gender selection of adolescents (and their parents) who were willing and able to come to the university laboratory. Further, study participants included only those who (1) reported a positive history of recent alcohol use over the phone and (2) met all physical (e.g., respiratory) and psychological (e.g., PTSD) screening requirements. Together, caution must be taken in terms of the generalizability of the current findings. For example, the majority of work conducted with adults has examined this relation among individuals with an AUD, PTSD, or both (Coffey et al., 2002; Saladin et al., 2003 Sharkansky et al., 1999; Stewart, 1996; Stewart et al., 2000). Although the current study excluded similarly diagnosed youth due to concerns related to the protection of human subjects (e.g., exacerbation of pre-existing symptoms) and methodological rigor (e.g., confounding effects of clinical conditions; Zvolensky et al., 2001), a growing research base indicates that alcohol-dependent individuals are at minimal risk for problematic outcomes following laboratory-based alcohol administration procedures (Pratt & Davidson, 2005), and a relatively

large body of work has utilized hyperventilation procedures among persons with various anxiety conditions, including PD and PTSD (e.g., Hawks et al., 2011; Rapee et al., 1992). Accordingly, extension of this work to clinical samples of youth is warranted, particularly in terms of determining whether the current data reflect disparate etiological versus maintenance-related mechanisms (cf. developmental differences). Further, future work would benefit from employing alternative sampling and screening procedures (e.g., via schools, community health centers) in an effort to obtain a more diverse sample as well as reduce potential sampling biases. For example, implementation of a preliminary screening assessment at a large middle/high school may (1) increase participant confidence in privacy and thus the potential sampling pool as well as (2) allow for targeted selection across both primary (e.g., alcohol-relevant and life experiences) and demographic (e.g., age, race) variables.

Finally, three additional design features must be considered. First, preliminary analyses indicated a failure of random assignment. Specifically, youth who were assigned to the hyperventilation task evidenced higher levels of negative affectivity as compared to those in the control task. Further, as can be seen in Table 1, the few "heavy smokers" (i.e., ≥ 10 cigarettes per day in the past month) in the sample were all assigned to the trauma exposed-hyperventilation group. It is important to note that this outcome actually could have increased Type 1 error (i.e., confounding group and task linkages with alternative, relevant associations); nonetheless, this is a key flaw of the current study and analytic approach (Miller & Chapman, 2001; Zinbarg, Suzuki, Uliaszek, & Lewis, 2010). Second, alcohol-relevant responding was indexed via self-reported desire to drink. Although this is a common technique in work conducted with adolescents (e.g., Tapert et al., 2003), experimental tasks such as assessing psychophysiological responding to alcohol-relevant cues (e.g., words, pictures; Lowman, Hunt, Litten, & Drummond,

2000; Sayette et al., 2000; Tapert et al., 2003) may represent more precise baseline and post-task assessments as compared to self-reported desire alone. For example, alcohol-relevant dichotic listening, dot probe, or implicit memory tasks may tap into features such as indirect learning experiences, automatic responding, or genetic disposition not captured by standard self-report assessments, and thus provide a more accurate predictor of actual consumption among adolescents (e.g., Sayette et al., 2000). Further, laboratory visits were scheduled at the participants' convenience, and thus occurred at varied times across the morning, afternoon, and evening. Standardizing the appointment time to hours during which drinking is most likely to occur (e.g., evening) may increase the power of drinking-related manipulations in future work. Finally, the current study was designed to assess a single, uni-directional relation (i.e., bodily arousal predicting desire to drink), and was underpowered to address the role of temporal precedent (e.g., initiation of alcohol use, traumatic event exposure; Blumenthal et al., 2008), potential third variables (e.g., impulse control; Henges & Marczinski, 2012), or mediating conditions (e.g., depressive symptoms; Karlović, Solter, Katinić, & Potkonjak, 2004; Saban, Flisher, & Distiller, 2010). Specifically, the current study drew upon a tension reduction model of the trauma cue-alcohol use linkage; however, for many youth alcohol use may instead increase risk for traumatic event exposure, the trauma-alcohol link may reflect the influence of a third variable, such as impulsivity or parental alcohol use, or traumatic event exposure may increase risk for alcohol use via an indirect effect, such as an increase in depressive symptoms which in turn increase alcohol use. The relative frequency and strength of disparate pathways linking trauma and problematic alcohol use will be key in forwarding this body of work, and future efforts focused on the self-medication linkage would benefit from honing in on selected subsamples of youth (e.g., based on temporal precedent, alcohol use expectancies, or behaviors).

Further, in addition to longitudinal, multivariate models, future experimental work could significantly advance this body of work via both sample selection and protocol design. For example, work contrasting alcohol-relevant outcomes (e.g., desire to drink, cue response) across laboratory-based trauma-cue and sadness inductions could aid in clarifying the relative roles of trauma-specific responding, as compared to co-occurring depressive symptoms, in predicting alcohol use behaviors among trauma exposed adolescents.

Taken together, the current study suggests that downward extension of work conducted with adults to models of alcohol use behaviors among trauma exposed adolescents may not capture the nature or boundaries of this relation as they exist during this distinct developmental period. The current manuscript provides several suggestions for future work in this domain, including research designed to parse apart social, developmental, clinical, and individual difference factors that could help explain the current set of findings as well as forward our understanding of the trauma-alcohol use link among youth generally.

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Footnote

[1] This sample is independent from that examined in the current study as well as prior work from this research team (Hawks et al., 2011).

Table 1.

Raw data mean (and standard deviation) of predictor and outcome variables as a function of task

and traumatic event history

	IAPS Control		Hyperventilation		Total
	No trauma	Trauma	No Trauma	Trauma	
DAQ_Baseline	63.60(37.79)	61.13(31.24)	67.66(39.30)	73.40(45.23)	67.09(38.63)
DAQ_Post	56.20(37.27)	52.59(24.26)	65.80(43.26)	61.92(44.72)	59.08(37.71)
DAQ_Δ	-7.40 (13.19)	-8.54(15.69)	-1.86(12.00)	-11.48(20.42)	-8.01(16.63)
SUDS_Baseline	1.90 (1.44)*	3.81 (1.99)*	2.80 (2.27)	3.48 (2.69)	3.22 (2.30)
SUDS_Post	1.80 (1.31)*[a]	3.72 (2.47)*[a]	4.33 (2.91)	4.84 (3.10)	3.97 (2.81)
SUDS_Δ	-0.10 (1.52)	-0.09 (2.67)	1.53 (3.35)	1.36 (3.52)	0.75 (3.06)
pCO_2_Baseline	39.66 (4.58)	37.66 (5.35)	35.13 (6.97)	35.44 (7.97)	36.53 (6.78)
pCO_2_Low	37.66 (5.87)	36.11 (5.34)	16.06 (7.85)[a]	16.28 (4.21)[a]	24.43(11.54)
pCO_2_Δ	2.00 (1.73)	1.55 (1.58)	19.06 (6.79)	19.16 (5.50)	12.10 (9.79)
Alcohol frequency	2.00 (1.24)	2.73 (1.20)	2.33 (0.97)	2.72 (1.06)	2.54 (1.12)
Negative affect	25.40 (8.50)	27.22 (9.10)	30.80(12.22)	32.80(12.00)	29.65(10.95)
Anxiety sensitivity	25.00 (2.66)	27.40 (3.73)	26.80 (6.43)	30.60 (8.21)	28.05 (6.32)
# Cigarettes/day	0.90 (1.91)	0.78 (1.40)	0.53 (0.89)[a]	2.56 (5.45)[a]	1.36 (3.47)
Age	15.85 (1.86)	16.00 (1.43)	16.54 (1.11)	16.09 (1.56)	16.12 (1.47)

Note. $N = 72$ ($n = 32$ control). DAQ: Desires for Alcohol Questionnaire (Love et al., 1998); _Δ:

Post minus Baseline (change). IAPS: International Affective Picture System (Center for the

Study of Emotion and Attention, 1995). pCO_2: Expired carbon dioxide; _Δ: Baseline minus

Task-low (change). SUDS: Subjective Units of Distress Scale (Anxiety; Perrin et al., 2000;

Wolpe, 1958); _Δ: Post minus Baseline (change).

[a] Within-task group variance significantly different, $p < .05$.

*Within-task group mean significantly different, $p < .05$.

Table 2.
Zero-order relations among continuous predictor and outcome variables as a function of traumatic event history (raw data)

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. DAQ_B	_	.88**	-.38**	-.20	-.03	.12	.08	-.15	.23	.52**	.16	.28*	.04	.24
2. DAQ_P	.95**	_	.08	-.29*	-.01	.20	.18	-.10	.24	.52**	-.01	.14	.04	.17
3. DAQ_Δ	.04	.34	_	-.13	.04	.14	.19	.11	.00	-.09	-.36*	-.34*	-.01	-.17
4. SUDS_B	.06	-.04	-.33	_	.25	-.51**	-.04	.09	-.14	-.06	.19	.00	-.23	-.06
5. SUDS_P	-.20	-.13	.18	.29	_	.69**	.08	-.14	.21	-.04	.03	.04	-.18	-.06
6. SUDS_Δ	-.23	-.09	.41*	-.42*	.74**	_	.10	-.19	.29	.00	-.11	.03	.00	.01
7. pCO_2_B	.08	.20	.40*	-.30	-.25	-.02	_	.47**	.18	.10	-.17	-.23	-.32*	-.20
8. pCO_2_Low	-.01	.01	.08	-.34	-.52**	-.24	.63**	_	-.77**	-.04	-.24	-.26	-.25	-.15
9. pCO_2_Δ	.06	.10	.15	.23	.50*	.29	-.16	-.86**	_	.12	.14	.12	.05	.00
10. AADIS	.57**	.45*	-.25	.11	.04	-.03	-.16	-.17	.12	_	-.11	-.10	-.12	.28
11. PANAS	.02	.05	.09	-.22	-.23	-.06	-.17	-.06	-.03	-.15	_	.59**	-.15	.11
12. CASI	.25	.30	.23	-.26	-.16	.03	.03	.13	-.15	.05	.70**	_	-.08	.05
13. SHQ	.41*	.34	-.16	.00	-.12	-.12	-.12	.09	-.20	.63**	-.02	.00	_	.08
14. Age	-.07	-.09	-.08	.12	.39*	.28	-.28	-.29	.18	.40*	-.11	.10	.18	_

Note. Data for traumatic event exposed youth are above the diagonal ($n = 47$); data for non-exposed youth are below the diagonal ($n = 25$). AADIS: Adolescent Alcohol and Drug Involvement Scale (Moberg, 2000). CASI: Child Anxiety Sensitivity Index (Silverman et al., 1991). DAQ: Desires for Alcohol Questionnaire (Love et al., 1998) _B: Baseline; _P: Post; _Δ: Post minus Baseline (change). PANAS: Positive and Negative Affect Schedule for Children (negative affect subscale; Joiner et al., 1996). pCO$_2$: Expired carbon dioxide; _B: Baseline; _Low: Task-low; _Δ: Baseline minus Task-low (change). SHQ: Smoking History Questionnaire ("In the past month (30 days) how many cigarettes did you smoke in an average day?"). SUDS: Subjective Units of Distress Scale (Anxiety; Perrin et al., 2000; Wolpe, 1958) _B: Baseline; _P: Post; _Δ: Post minus Baseline (change).

*$p < .05$ **$p < .01$

Table 3.

Participant responses when asked about thoughts during the task as a function of group and condition

Group	Response	Frequency
No trauma - IAPS		
	Nothing in particular	8
	Ready to be done with visit	1
	Pictures repetitive	1
Trauma - IAPS		
	Nothing in particular	13
	Tired/sleep	2
	Ready to be done with visit	1
	Boyfriend	1
	Drumline (band)	1
	Reminded of old neighborhood (fire hydrant picture)	1
	Making up stories for pictures	1
	School, clothes	1
	Waiting for something to happen	1
No trauma - Hyperventilation		
	Nothing in particular	12
	Cannot remember	1
	Friends, music	1
	Task weird (but not aversive)	1
Trauma - Hyperventilation		
	Nothing in particular	13
	Thoughts of trauma(s)	2
	Dizzy feeling	2
	Focused on task/instructions	2
	Task felt long	2
	Task felt short	1
	Made sleepy	1
	Wanted to get out	1
	Whether/not to finish; went to peaceful time/place	1