

The Influences of PTSD and Distress Tolerance on Trauma and Alcohol Cue Reactivity

BY

Katherine C. Paltell
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THESIS

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Defense Committee:

Erin Berenz, Chair, Advisor, UIC Psychology
Ellen Herbener, UIC Psychology
Grace Giedgowd, UIC Psychology

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LIST OF ABBREVIATIONS

PTSD	Posttraumatic Stress Disorder
AUD	Alcohol Use Disorder
DT	Distress Tolerance
DSM-5	Diagnostic and Statistical Manual of Mental Disorders- Fifth Edition
DTS	Distress Tolerance Scale
SUDS	Subjective Units of Distress Scale
PANAS	Positive and Negative Affect Schedule
MINI	Mini International Neuropsychiatric Interview for DSM-5
CAPS-5	Clinician-Administered PTSD Scale for DSM-5
AUDIT	Alcohol Use Disorders Identification Test

SUMMARY

Self-medication models posit that posttraumatic stress disorder (PTSD) increases risk for developing alcohol use disorder (AUD), as individuals may use alcohol to cope with their trauma-related negative affect and memories. However, successfully treating PTSD does not improve AUD outcomes compared to standard AUD treatment alone, suggesting that clinically impacting self-medication in PTSD-AUD may be nuanced. One promising clinical intervention target to decrease self-medication is distress tolerance (DT). The current study used a trauma and alcohol cue reactivity paradigm, which measures alcohol craving in response to four combinations of narrative (trauma or neutral) and beverage (alcohol or water) cues, to elucidate the role of DT in comorbid PTSD-AUD. Participants were 185 university students (50.3% female) who reported a history of interpersonal trauma and current alcohol consumption. Forward-fitted linear mixed effects models were used to examine (a) the influence of the within-subjects factors (narrative cue, beverage cue) and covariates (DT, PTSD symptoms) on alcohol craving, and (b) the role of DT in a moderated-mediation model of self-medication. Contrary to prediction, DT did not significantly interact with narrative cue to predict craving ($\beta = 0.189$, $p = .184$). However, DT significantly interacted with beverage cue in relation to craving ($\beta = -0.293$, $p = .011$), such that individuals low, as compared to high, in DT reported greater craving for alcohol in response to the alcohol, but not water, beverage cue. In the context of a moderated-mediation model of self-medication, DT did not moderate the association between negative affect and craving ($t = 0.630$, $p = .529$), or an association between trauma cue and negative affect ($t = -0.674$, $p = .501$). The findings suggest that among trauma-exposed young adult drinkers, low DT may not exacerbate self-medication use. Instead, DT may influence alternative processes of AUD risk, such as susceptibility to conditioned craving responses to alcohol.

I. INTRODUCTION

Posttraumatic stress disorder (PTSD) and alcohol use disorder (AUD) cooccur frequently (Kessler et al., 1995), and approximately half of people seeking AUD treatment also meet diagnostic criteria for PTSD (Brown et al., 1999). Interpersonal trauma (e.g., physical/sexual assault), relative to non-interpersonal trauma (e.g., natural disasters, motor vehicle accidents), is associated with increased risk for PTSD (Kessler et al., 1995) and greater alcohol use (i.e., frequency and quantity; Berenz et al., 2016; Overstreet et al., 2017), as well as alcohol use problems (Rice et al., 2001; Volpicelli et al., 1999).

College populations are at particularly high risk for both interpersonal trauma (Overstreet et al., 2017; Read et al., 2012) and problem drinking (Hingson et al., 2006; Jackson & Sartor, 2016; Kessler et al., 2005; O'Malley & Johnston, 2002; Overstreet et al., 2017; Read et al., 2012). Up to 39% of college students endorse lifetime exposure to potentially traumatic events (PTEs) that are interpersonal in nature (Overstreet et al., 2017). Further, AUD symptomology often emerges during young adulthood, with severe AUD presenting at a mean age of 23.9 years (National Epidemiologic Survey for Alcohol and Related Conditions, 2015). Two-thirds of college students endorse past-month drinking, and almost half endorse past-two-week binge drinking, an established risk factor for AUD (O'Malley & Johnston, 2002). College students also drink more heavily and frequently than their non-enrolled, same age peers (Johnston et al., 2014; O'Malley & Johnston, 2002). Associations between trauma and alcohol phenotypes are well established in college samples. Among college students, a history of interpersonal trauma exposure is associated with increased alcohol use and trauma-related distress (Overstreet et al., 2017; Read et al., 2012). In turn, alcohol use problems following interpersonal trauma may increase risk for sexual assault revictimization (Messman-Moore & Long, 2003). Taken together,

college represents a developmentally sensitive period for the onset of trauma-related symptoms and AUD.

A. Self-Medication Theory of PTSD-AUD Risk

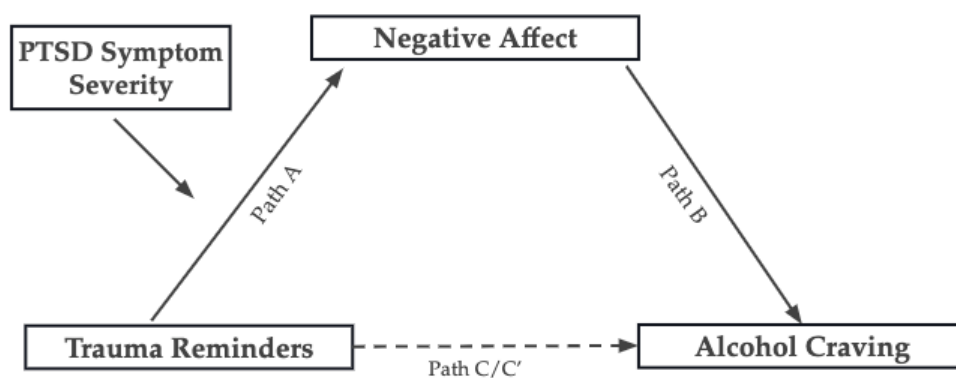
A common explanation for PTSD-AUD comorbidity is the self-medication model, which postulates that individuals with PTSD are at greater risk of developing AUD as they may use alcohol to cope with their trauma-related negative affect and memories (Khantzian, 1999; O'Hare & Sherrer, 2011; Waldrop et al., 2007). Self-medication models of PTSD and alcohol use have been well-supported by the empirical literature. Individuals with PTSD report coping-orientated drinking more often than those without PTSD (Filipas & Ullman, 2006; Waldrop et al., 2007), and coping-oriented alcohol use partially mediates the association between PTSD and alcohol use problems (O'Hare & Sherrer, 2011). Laboratory experimental designs have been particularly useful in furthering our understanding of self-medication risk. In cue reactivity paradigms, for example, emotional, behavioral, and physiological responses are induced by both internal (e.g., memories, emotions) and external (e.g., images, smells) trauma- and substance-related cues (Coffey et al., 2002). The trauma and alcohol cue reactivity paradigm measures self-reported and physiological craving for alcohol in response to four combinations of narrative (trauma vs. neutral) and beverage (alcohol vs. water) cues. Prior research utilizing this paradigm has found that individuals with comorbid PTSD-AUD display self-reported and physiological (i.e., salivation) craving in response to trauma memories even when no alcohol is present (Coffey et al., 2002; Coffey et al., 2006), and that cue-elicited craving for alcohol decreases following PTSD remission (Nosen et al., 2014). Consistent with the self-medication hypothesis, these findings indicate that there may exist a learned association between trauma reminders and alcohol use.

However, clinical trials conducted in individuals in AUD treatment have shown that successfully treating PTSD does not improve AUD outcomes (e.g., relapse rates) compared to standard AUD treatment alone (Coffey et al., 2016; Ruglass et al., 2017), suggesting that clinically impacting self-medication in PTSD-AUD may be nuanced. Emerging research exploring this nuanced relationship has indicated that breaking an association between negative affect and drinking, in addition to addressing major sources of negative affect (e.g., PTSD symptoms), may be necessary for decreasing self-medication alcohol use. Indeed, peripheral literature on comorbid anxiety-AUD treatment outcomes has posited that the failure to fully account for the learned association between anxiety symptoms (e.g., negative affect) and alcohol consumption in treatment protocols may contribute to the inability of anxiety treatment to enhance alcohol outcomes (Kushner et al., 2000; Kushner et al., 2013).

To elucidate the influences of negative affect on self-medication risk, data collected through our lab's trauma and alcohol cue reactivity paradigm was used to establish a mediation model of the relationship among trauma cues, negative affect, and alcohol craving in trauma-exposed university students (Berenz et al., in preparation; see Figure 1). Results of this mediation model revealed that negative affect fully mediates the association between trauma cues and craving for alcohol, such that increases in negative affect following exposure to personalized trauma memories elicit greater subjective alcohol craving. PTSD symptoms moderated the pathway from trauma cue to negative affect, such that trauma cues evoked elevated negative affect among those higher compared to lower in PTSD symptom severity. However, PTSD symptom severity did not moderate the pathway from negative affect to craving. Currently, there exists a dearth of literature exploring potential moderators of this association between negative affect and alcohol craving, which is thought to maintain self-medication alcohol use. Studies

examining modifiers of the association between negative affect and craving would advance PTSD-AUD self-medication theory and inform the development of novel clinical interventions targeting self-medication drinking in PTSD-AUD.

Figure 1
Established Moderated-Mediation Model of Trauma Cue-Elicited Craving



Berenz et al., in preparation

Distress tolerance (DT), defined as the perceived capacity to withstand negative emotional and/or other aversive states (Leyro et al., 2010), exhibits theoretical and empirical promise as a possible intervention target to decrease self-medication drinking in individuals with comorbid PTSD-AUD. Individuals with low DT believe that they are unable to cope with the experience of negative affect, and tend to engage in a variety of emotional avoidance behaviors (Buckner et al., 2007; Leyro et al., 2010; Simons & Gaher, 2005). Specifically, low DT is associated with various negative psychiatric outcomes, including coping-oriented alcohol use (Marshall-Berenz et al., 2011; Howell et al., 2010; Simons & Gaher, 2005) and problem drinking

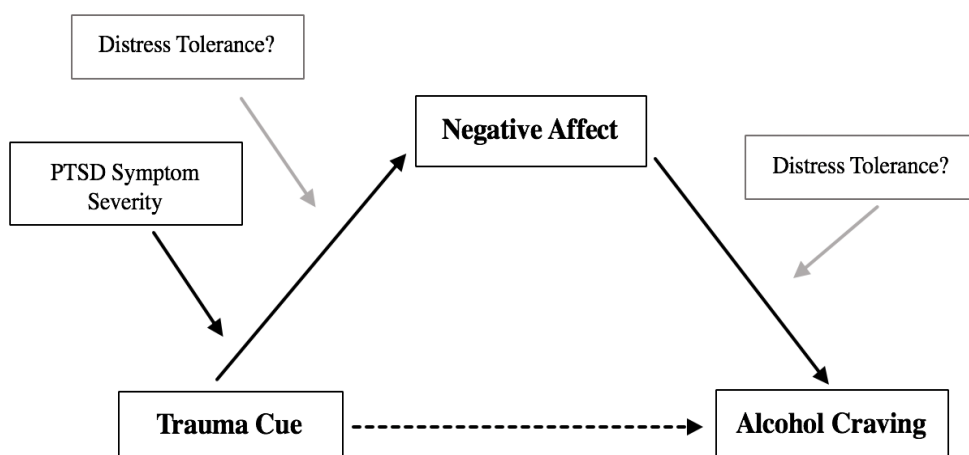
(Buckner et al., 2007; Simons & Gaher, 2005). In trauma-exposed samples, low DT has been identified as a partial mediator of the association between PTSD symptoms and alcohol use coping motives (Vujanovic et al., 2011), and alcohol consumption has been found to be elevated in adults with low DT who endorse PTSD symptoms (Duranceau et al., 2014). Taken together, it is possible that trauma exposed individuals with lower perceived capacities to withstand emotional distress use alcohol as a means to cope with the negative affect elicited by their trauma reminders. However, the majority of work exploring relationships among PTSD, DT, and coping motives for alcohol has relied on cross-sectional survey methods as opposed to laboratory designs geared towards the evaluation of self-medication, such as the trauma and alcohol cue reactivity paradigm. Elucidating the role of DT in trauma-related alcohol risk would inform clinical models of PTSD-AUD and self-medication alcohol risk more broadly. If DT proves relevant to the negative affect-craving association, DT interventions may bolster PTSD-AUD interventions by disrupting the link between negative affect and alcohol craving and use.

B. Study Aims

The current study examined the role of DT in trauma and alcohol cue reactivity (i.e., craving and salivation) in a sample of university students who endorsed a history of interpersonal trauma and current, weekly alcohol consumption. It was hypothesized that (a) DT would interact with trauma cues to predict elevated craving and salivation, such that individuals low in DT would exhibit greater subjective and physiological responses to trauma cues, compared to those high in DT. Exploratory analyses also were conducted to evaluate whether DT moderated an association between alcohol cues and craving and salivation. In the context of the negative affect mediation model of trauma cue-elicited craving (Berenz et al., in preparation), it also was hypothesized that (b) DT would moderate an association between negative affect and alcohol

craving (see Figure 2, path b), but not an association between trauma cues and negative affect (Figure 2, path a).

Figure 2
Proposed Model of Moderated Mediation



II. METHOD

A. Study Overview

This study utilized data from an R00 at UIC that completed data collection in the spring of 2019. Data collection was comprised of three components: a preliminary phone screen, a first session to obtain trauma and alcohol cue information, and a second laboratory session. A trauma and alcohol cue reactivity paradigm (modeled after Coffey et al., 2002) was used for the laboratory session to evaluate the influence of DT on self-reported alcohol craving in response to personalized trauma and alcohol cues. Interested individuals were contacted by a member of the research team via phone or email to participate in a preliminary phone screen. Eligible individuals were scheduled to participate in Session 1, during which they completed a battery of questionnaires and clinical interviews that were used to obtain their personalized trauma and alcohol cue information. If eligible, individuals were then scheduled for the Session 2 laboratory session.

B. Participants

Participants included 185 college students (50.3% female). 95 of these students were recruited from the University of Virginia, while the remaining were from universities in the Chicago metropolitan area. Recruitment materials were paper flyers and online advertisements (e.g., Craigslist, Facebook) directed towards survivors of interpersonal trauma who use alcohol regularly.

Eligible participants were university students between the ages of 18-25 with a history of one or more potentially traumatic events meeting *DSM-5* Criterion A for PTSD; these events were required to be interpersonal in nature (e.g., sexual/physical assault, witnessing family violence). Eligible participants also endorsed current weekly alcohol use (i.e., at least bi-weekly)

and needed to be able to provide consent and complete study procedures in English. In addition to not meeting the aforementioned inclusion criteria, individuals were excluded from participation if they endorsed current use of craving-reducing medications (e.g., Naltrexone) or medications that may interfere with cue-elicited craving or salivation (e.g., tricyclic antidepressants). Individuals were also excluded if they endorsed current or past participation in exposure-based therapy for PTSD symptoms and current or recent (past 6-month) participation in an alcohol or substance use treatment program.

C. Measures

1. Screening Measures (Session 1)

Current weekly alcohol use was assessed via a 90-day experimenter-administered Timeline Follow-back (TLFB; Sobell & Sobell, 1992). Illicit and prescription drug use was also queried with regard to this 90-day period. Individuals who did not endorse regular alcohol use in the 30 days prior to Session 1 were excluded from participation in Session 2.

Self-reported alcohol use problems were assessed using the Alcohol Use Disorders Identification Test (AUDIT; Babor et al., 1992), a 10-item screening tool widely used for assessing alcohol use problems. Participants responded to questions (e.g., “How often during the last year have you found that you were not able to stop drinking once you had started?”) on a Likert scale ranging from 1 to 4, with higher scores reflecting greater problem severity.

Distress tolerance was measured via the Distress Tolerance Scale (DTS; Simons & Gaher, 2005). This 15-item self-report instrument is designed to measure the extent to which individuals can withstand distressing affective states. Participants responded to questions (e.g., “I’ll do anything to stop feeling distressed or upset”) using a Likert scale ranging from (1) *strongly agree* to (5) *strongly disagree*.

Interpersonal trauma history was evaluated via the Traumatic Life Events Questionnaire (TLEQ; Kubany et al., 2000), a 23-item self-report measure that queries for a range of PTEs (both interpersonal and non-interpersonal). The TLEQ assessed the number of times each endorsed event occurred, and whether these events were directly experienced, witnessed, or learned about. Presence of intense fear, horror, or helplessness during the event and serious injury as a result of the event was also queried. The TLEQ has demonstrated good test-retest reliability and convergent validity with trauma interview assessments (Kubany et al., 2000).

Alcohol drinking motives were assessed using the Drinking Motives Questionnaire-Revised (DMQ-R; Cooper, 1994). The DMQ-R is a 20-item self-report measure designed to assess reasons why people might be motivated to drink alcohol. Participants rated on a 5-point Likert-style scale how frequently each of the listed reasons motivate them to drink alcohol. This measure yields four subscales: Social (i.e., “Because it improves parties and celebrations”), Coping (i.e., “To forget your worries”), Enhancement (i.e., “Because you like the feeling”), and Conformity (i.e., “Because your friends pressure you to drink”).

2. Diagnostic Measures (Session 1)

PTSD symptoms were assessed via the Clinician Administered PTSD scale for DSM-5 (CAPS-5; Weathers et al., 2015), a diagnostic interview for current and lifetime PTSD symptoms that uses *DSM-5* diagnostic criteria. The CAPS-5 was completed with regard to all interpersonal potentially traumatic events meeting Criterion A for PTSD that were endorsed by the participant. CAPS-5 responses were used to establish a current (past 30 day) continuous PTSD symptom severity score (i.e., CAPS-5 total score) and diagnostic label (i.e., present vs. absent) for each participant.

DSM-5 diagnostic criteria for anxiety and mood disorders, substance use disorders, eating disorders, and psychotic symptoms was assessed using the Mini-International Neuropsychiatric Interview (MINI; Sheehan et al., 1998). Information obtained through this semi-structured interview was used to determine whether participants met *DSM-5* criteria for AUD, as well as the associated severity (i.e., mild, moderate, severe) of the AUD diagnosis.

3. *Personalized Narrative and Beverage Cues (Session 1)*

The participant's personalized trauma narrative was constructed following a detailed account of their self-identified worst interpersonal traumatic event. The participant's personalized beverage cue was obtained by querying their most frequently consumed alcoholic beverage (e.g., brand of alcohol, beverage container, mixers, ice, etc.).

4. *Laboratory Measures (Session 2)*

Craving for alcohol was assessed via three questions on a 0-10 Likert-type scale: "I crave a drink right now;" "I want a drink right now;" and "I have a desire for a drink right now" (Kozlowski et al., 1996). Participants were asked to rate their craving for alcohol following each of the four cue reactivity trials. In the current study, craving ratings were used as a primary outcome measure.

Pre-weighed cotton dentals rolls were used to measure participant's physiological salivary response to alcohol and trauma cues. At the start of each trial, three pre-weighed dental rolls were inserted into the participant's mouth. Immediately following each trial, the dental rolls were removed and weighed to determine the magnitude of salivation, which was used as a primary outcome measure in the current study.

The Positive and Negative Affect Schedule (PANAS; Watson et al., 1988) was used to assess cue-related changes in positive and negative affect. Participants were asked to rate 20

different feelings and emotions (e.g., “excited”) on a scale of 1-5 (with 1 being very slightly or not at all representative of how they are feeling at that moment, and 5 being extremely representative of their feelings at that moment) following each trial. In the present study, ratings from the negative affect subscale of the PANAS were utilized in the primary mediation model.

The Subjective Units of Distress Scale (SUDS; Wolpe, 1958) was used to measure participant’s emotional distress on a 0-100 point scale (0 = “totally relaxed” and 100 = “highest distress/fear/anxiety/discomfort that you have ever felt”). Participants were asked to rate their SUDS level following the completion of each of the four cue reactivity trials. For the current study, SUDS ratings were used in the context of manipulation checks, to ensure trauma cues elicited greater distress than neutral cues.

D. Procedure

Interested individuals were contacted by a member of the research team via phone or email to participate in a preliminary phone screen that assessed inclusion and exclusion criteria. Following the phone screen, eligible individuals were scheduled for Session 1, during which current alcohol use and Criterion A potential traumatic event exposure was confirmed. Participants who did not meet these criteria completed the session and received compensation, but were not scheduled for Session 2. If participants could not verify student status or endorsed suicidality, the session was terminated early.

1. Session 1

Session 1 lasted approximately 2.5 to 3 hours. Following consent, participants completed a battery of self-report measures, including demographics, the DTS, and the TLEQ. A member of the research team administered the TLFB and queried participant’s preferred alcoholic beverage. The CAPS-5 and MINI were administered by a trained Masters-level or doctoral student, after

which a detailed personalized trauma narrative of participant's self-identified worst traumatic event was obtained. This narrative was adapted into a 60-second audio recording for use during Session 2. Participants who met inclusion criteria for Session 2 were compensated and scheduled for Session 2 ideally within two weeks, but up to 30 days, from their Session 1 date. Participants were instructed to abstain from alcohol for 24 hours prior to Session 2.

2. Session 2

The laboratory session lasted up to 90 minutes. A breathalyzer test was first used to verify participants' abstinence from alcohol. Participants were also queried for their most recent alcohol, nicotine, and caffeine use, and for the number of hours they slept the previous night. Participants were seated in a comfortable chair with an adjustable-height table for cue presentation, and a non-recording video camera was assembled to monitor participants from behind a room partition.

At the start of each cue presentation, pre-weighed cotton dental rolls were placed in the participant's mouth. The participant was then instructed to put on headphones and close their eyes. A 60-second audio narrative (personalized trauma narrative or neutral narrative about a person changing a lightbulb) was then presented over the headphones. During this period, a beverage cue (preferred alcoholic beverage or water) was placed on the adjustable table directly in front of the participant. After 1 minute, the narrative cue ended, and the participant opened their eyes. The participant was instructed to actively imagine the narrative scene for 2 minutes while viewing the beverage cue. After this 2-minute period, the dental rolls were removed and weighed, and the participant completed a variety of self-report measures, including the craving questionnaire, SUDS, and PANAS. The cotton dental rolls were weighed to measure magnitude of salivation. These procedures were completed five total times. There was a practice trial

(neutral narrative and beverage cues) that was followed by four experimental trials, consisting of all four possible cue combinations: (1) neutral narrative cue and water cue (2) neutral narrative cue and alcohol cue, (3) trauma narrative cue and water cue, and (4) trauma narrative cue and alcohol cue. All four cue combinations were fully counterbalanced between and within subjects by gender.

E. Analytic Approach

Manipulation checks were conducted via a within-subjects analysis of variance (ANOVA) to verify that the trauma narrative conditions evoked greater distress (i.e., SUDS) than the neutral narrative conditions, and that the alcohol cue conditions evoked greater self-reported craving for alcohol than the water conditions. Best-fitting models for both craving and salivation analyses were established (Berenz et al., in preparation) through use of forward-fitting linear mixed effects models with deviance testing (parsimonious random effects; Bates, Kliegl, Vasishth, & Baayen, 2015; Matuschek, Kliegl, Vasishth, Baayen, & Bates, 2017).

For craving, the best-fitting model included narrative cue (i.e., 0=neutral, 1=trauma), beverage cue (0=water, 1=alcohol), the covariates of cumulative trauma history (i.e., number of traumatic event categories endorsed on the TLEQ), data collection site (i.e., UVA vs. UIC), and alcohol use frequency (i.e., number of drinking days in last 30 days), as well as a PTSD*narrative cue interaction term. The current study built upon this best-fitting model to evaluate a) the main effect of distress tolerance on trauma and alcohol cue reactivity (i.e., self-reported craving), and b) whether distress tolerance modified the effect of trauma cues on craving.

For salivation, the best fitting model included narrative cue (i.e., 0=neutral, 1=trauma), beverage cue (0=water, 1=alcohol), the covariates of cumulative trauma and data collection site,

and a PTSD*narrative cue interaction term. Similarly, the present study built upon this model to evaluate a) the main effect of distress tolerance on trauma and alcohol cue reactivity (i.e., salivation) and b) whether the effect of trauma cues on salivation was modified by distress tolerance, above and beyond the covariate of data collection site. For both craving and salivation analyses, these best-fitting models served as referents for model comparison, to assess whether subsequent models were of superior fit.

The present study also evaluated whether DT moderates either path in the negative affect mediation model (see Figure 2, paths a and b). The current mediation model utilized forward-fitting linear effects models to establish: a) that trauma cues significantly predict craving for alcohol; b) that trauma cues significantly predict the mediator (i.e., negative affect; PANAS; Watson et al., 1988); c) when trauma cue and negative affect are entered into the model simultaneously, negative affect significantly predicts craving, and the relationship between trauma cues and craving is diminished; and d) PTSD symptom severity moderated the association between trauma cue and negative affect, such that greater PTSD symptom severity predicted greater negative affect. The current study built on this existing mediation model to evaluate whether distress tolerance moderates the pathways of trauma cue to negative affect or negative affect to craving.

III. RESULTS

A. Sample Characteristics and Descriptive Statistics

Descriptive statistics are presented in Table 1. An approximately equal number of men and women were included in this racially diverse sample. On average, participants endorsed exposure to six different types of traumatic events. The most frequently endorsed interpersonal traumas included witnessing family violence and witnessing physical assault by a stranger, followed by adult sexual assault. Approximately half of the participants met criteria for a past-month diagnosis of PTSD, and more than three quarters of the sample met criteria for current AUD, as measured by the MINI. Of those participants with current AUD, almost one third met criteria for severe AUD.

TABLE I**PARTICIPANT DEMOGRAPHICS AND CHARACTERISTICS (*N* = 185)**

Variable	Total M(<i>SD</i>) or %
Gender	(50.3% Female)
Race	
African American	12.4%
Asian	17.3%
Caucasian/White	53.5%
Multi-Racial	9.2%
Other	6.5%
Ethnicity	
Hispanic	15.1%
Not Hispanic	83.2%
Interpersonal Trauma Types	
Armed robbery	21.6%
Physical assault by stranger	25.4%
Witnessed physical assault by stranger	42.2%
Threatened death or serious injury	36.8%
Physical abuse growing up	26.5%
Witnessed family violence growing up	43.2%
Physical assault by intimate partner	24.3%
Childhood sexual assault before age 13 (by s/o ≥ 5 years older)	17.8%
Childhood sexual assault before age 13 (by s/o close in age)	7.0%
Sexual assault (between 13 and 18)	20.0%

Sexual assault as adult (18 or older)	41.1%
Accidental Trauma Types	
Natural disaster	50.3%
Motor vehicle accident	27.6%
Other accident	21.6%
Unexpected death of a loved one	67.6%
Loved one survived life-threatening illness/accident	50.3%
Life-threatening illness (self)	7.6%
Number of Lifetime Trauma Types	6.59 (3.32)
Total PTSD Symptom Severity	15.04 (11.30)
Past-Month PTSD Diagnosis	49.2%
DTS Total Score	44.41(11.70)
AUDIT Total Score	11.95 (5.89)
Current MINI AUD Diagnosis	82.7%
Mild	36.6%
Moderate	30.7%
Severe	32.7%
Alcohol Use Quantity (past 30 days)	4.45(2.08)
Alcohol Use Frequency (past 30 days)	10.37 (4.89)
Alcohol Binge Frequency (past 30 days)	4.82 (4.15)

B. Zero-Order (Bivariate) Correlations

Correlations among the primary study variables are presented in Table 2. Data collection at UIC was significantly associated with a greater cumulative trauma and coping motives for alcohol use (DMQ-R Coping Motives subscale total score), as well as greater past-month alcohol use frequency. Alcohol use frequency was positively correlated with cumulative trauma, coping motives, and alcohol use problems (AUDIT total score). DT (DTS total score) was significantly inversely associated with all continuous variables except for alcohol use frequency, with the strongest association existing between DT and coping motives. Consistent with prior studies of alcohol cue reactivity (Kaplan et al., 1985; Ooteman et al., 2006; Tiffany, 1990), self-reported craving and salivation by trial (TA; TN; NA; NN) were not significantly correlated ($p > .05$).

TABLE II

ZERO-ORDER (BIVARIATE) CORRELATIONS

Variable	1	2	3	4	5	6	7	Mean (SD)
1. Data collection site	—							--
2. Cumulative trauma	.29**	—						6.59 (3.32)
3. Alcohol use frequency	.20**	.18*	—					10.37(4.89)
4. CAPS-5 total score	.08	.51**	.12	—				15.04 (11.30)
5. DTS total score	-.04	-.25**	-.12	-.48**	—			44.41 (11.70)
6. AUDIT total score	.12	.33**	.45**	.29**	-.25**	—		11.95 (5.89)
7. DMQ coping motives	.25**	.33**	.21**	.41**	-.53**	.41**	—	12.49(5.31)

Note: ** $p < .01$, * $p < .05$.

C. Manipulation Checks

Manipulation checks were conducted via a within-subjects analysis of variance (ANOVA) to verify that the trauma narrative conditions evoked greater distress (i.e., SUDS) than the neutral narrative conditions, and that the alcohol cue conditions evoked greater self-reported craving for alcohol than the water conditions. Results of manipulation checks indicated that the trauma narrative conditions (TA: $M = 53.69$, $SE = 1.96$; TN: $M = 48.92$, $SE = 1.96$) evoked higher SUDs ratings than the neutral narrative conditions (NA: $M = 15.55$, $SE = 1.21$; NN: $M = 15.67$, $SE = 1.23$; $F(1,190) = 684.49$, $p < .001$). Additionally, the alcohol cues (TA: $M = 4.28$, $SE = 0.22$; NA: $M = 3.25$, $SE = 0.18$) elicited greater craving than the water cues (TN: $M = 2.85$, $SE = 0.19$; NN: $M = 1.81$, $SE = 0.16$), and all three experimental conditions (i.e., TA, TN, and NA) elicited greater craving than the neutral-neutral cue condition ($F(1,190) = 148.928$, $p < .001$).

D. Moderating Role of DT on Trauma and Alcohol Cue Reactivity (Aim 1)

For subjective craving, the addition of DT to the craving base model (Model 1a) did not improve model fit ($p > .05$), and the main effect of DT in relation to subjective craving trended towards statistical significance (Model 1b; $\beta = -0.281$, $p = .074$). Contrary to prediction, DT did not significantly interact with narrative cue to predict craving (Model 1c; $\beta = 0.189$, $p = .184$). However, DT did significantly interact with beverage cue in relation to craving (Model 1d; $\beta = -0.293$, $p = .011$). Graphical examination of the interaction (Figure 3) indicated that individuals low, as compared to high, in DT reported greater craving for alcohol in response to the alcohol, but not water, beverage cue. See Table 3 for model fit statistics.

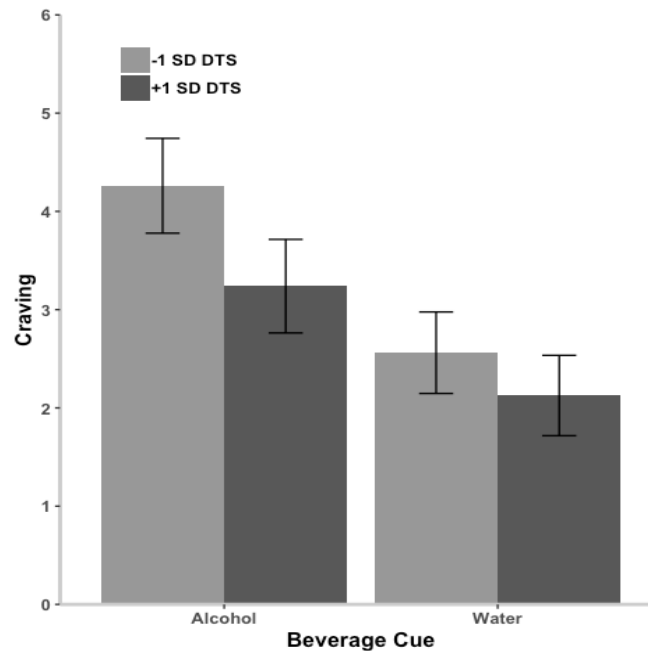
TABLE III

ESTIMATES, STANDARD ERROR, AND MODEL FITS FOR CRAVING

	Model 1a	Model 1b	Model 1c	Model 1d
(Intercept)	1.48*** (0.20)	1.48*** (0.20)	1.48*** (0.20)	1.48*** (0.20)
Narrative Cue: Trauma	1.06*** (0.12)	1.06*** (0.12)	1.06*** (0.12)	1.06*** (0.12)
Beverage Cue: Alcohol	1.40*** (0.12)	1.40*** (0.12)	1.40*** (0.12)	1.41*** (0.11)
Cumulative Trauma	0.11 (0.16)	0.13 (0.16)	0.13 (0.16)	0.13 (0.16)
Data Collection Site	0.69* (0.28)	0.68* (0.28)	0.68* (0.28)	0.68* (0.28)
Alcohol Use Frequency	0.45** (0.14)	0.42** (0.14)	0.42** (0.14)	0.42** (0.14)
PTSD Symptoms	0.76*** (0.16)	0.62*** (0.18)	0.59** (0.18)	0.61*** (0.18)
PTSD Symptoms*Narrative Cue	0.45*** (0.12)	0.45*** (0.12)	0.54*** (0.14)	0.47*** (0.12)
DT		-0.28 (0.16)	-0.34* (0.16)	-0.22 (0.16)
DT*Narrative Cue			0.19 (0.14)	
DT*Beverage Cue				-0.29* (0.11)
AIC	3112.18	3111.11	3111.41	3106.72
BIC	3181.60	3185.16	3190.09	3185.40
Log Likelihood	-1541.09	-1539.56	-1538.71	-1536.36
Num. obs.	756	756	756	756
N	185	185	185	185
Var: ID (Intercept)	2.68	2.64	2.65	2.64
Var: ID Narrative Cue: Trauma	1.26	1.26	1.25	1.26
Var: ID Beverage Cue: Alcohol	1.01	1.01	1.01	0.93
Cov: ID (Intercept) Narrative Cue: Trauma	-0.16	-0.13	-0.14	-0.14
Cov: ID (Intercept) Beverage Cue: Alcohol	0.18	0.11	0.09	0.12
Cov: ID Narrative Cue: Trauma Beverage Cue: Alcohol	0.35	0.35	0.40	0.38
Var: Residual	1.51	1.51	1.51	1.51

Note: *** $p < .001$, ** $p < .01$, * $p < .05$.

Figure 3
Association between Beverage Cues and Subjective Craving for Alcohol at Low and High Levels of Distress Tolerance



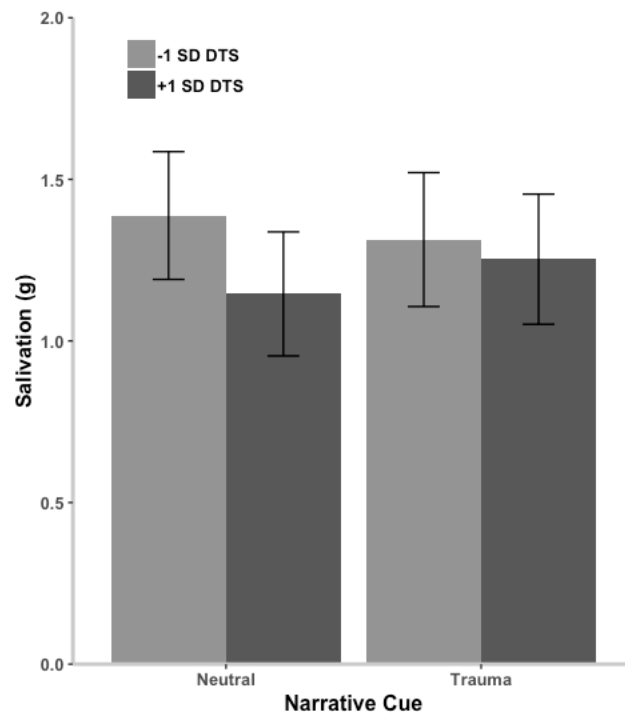
For salivation, the addition of DT to the base model (Model 2a) did not improve model fit ($p > .05$), and there was no main effect of DT on salivation (Model 2b; $\beta = -0.092, p = .217$). There was a significant interaction of DT and narrative cue in relation to salivation (Model 2c; $\beta = 0.091, p = .029$). Graphical examination of the interaction (Figure 4) indicated that low DT, as compared to high DT, was associated with greater salivation in response to the neutral narrative, but not the trauma narrative. There was no significant interaction of DT and beverage cue (Model 2d; $\beta = -0.043, p = .181$), and the addition of this interaction did not improve fit beyond Model 2a ($p > .05$). See Table 4 for model fit statistics.

TABLE IV

ESTIMATES, STANDARD ERROR, AND MODEL FITS FOR SALIVATION				
	Model 1	Model 2	Model 3	Model 4
(Intercept)	1.20*** (0.09)	1.20*** (0.09)	1.20*** (0.09)	1.20*** (0.09)
Narrative Cue: Trauma	0.02 (0.04)	0.02 (0.04)	0.02 (0.04)	0.02 (0.04)
Beverage Cue: Alcohol	0.12*** (0.03)	0.12*** (0.03)	0.12*** (0.03)	0.12*** (0.03)
Cumulative Trauma	0.16* (0.08)	0.16* (0.08)	0.16* (0.08)	0.16* (0.08)
Data Collection Site	-0.00 (0.13)	-0.00 (0.13)	-0.00 (0.13)	-0.00 (0.13)
PTSD Symptoms	-0.12 (0.08)	-0.16 (0.09)	-0.18* (0.09)	-0.16 (0.09)
PTSD Symptoms*Narrative Cue	0.09* (0.04)	0.09* (0.04)	0.13** (0.04)	0.09* (0.04)
DT		-0.09 (0.07)	-0.12 (0.08)	-0.07 (0.08)
DT*Narrative Cue			0.09* (0.04)	
DT*Beverage Cue				-0.04 (0.03)
AIC	1407.53	1408.01	1405.21	1408.21
BIC	1458.21	1463.29	1465.10	1468.09
Log Likelihood	-692.77	-692.00	-689.60	-691.10
Num. obs.	740	740	740	740
N	185	185	185	185
Var: ID (Intercept)	0.70	0.69	0.69	0.69
Var: ID Narrative Cue: Trauma	0.08	0.08	0.08	0.08
Var: ID Beverage Cue: Alcohol	0.03	0.03	0.03	0.03
Var: Residual	0.16	0.16	0.16	0.16

Note. *** $p < .001$, ** $p < .01$, * $p < .05$.

Figure 4
Association between Narrative Cues and Salivation at Low and High Levels of Distress Tolerance



E. Addition of DT to Moderated-Mediation Model of Craving (Aim 2)

Contrary to prediction, DT did not moderate the association between negative affect and craving (Figure 2, path b; $t = 0.630$, $p = .529$). DT also did not moderate an association between trauma cue and negative affect, above and beyond the established interaction between trauma cue and PTSD symptom severity (Figure 2, path a; $t = -0.674$, $p = .501$).

IV. DISCUSSION

The present study examined the role of DT in trauma and alcohol cue reactivity (i.e., craving and salivation) among university students endorsing a history of interpersonal trauma and current, weekly alcohol consumption. The first aim of this study was to examine the effects of DT on trauma and alcohol cue-elicited craving and salivation, above and beyond established main and interactive effects of PTSD symptom severity. Given prior literature documenting increased coping-oriented drinking among those low in DT (Marshall-Berenz et al., 2011; Howell et al., 2011; Simons & Gaher, 2005), it was hypothesized that individuals low in DT would exhibit greater subjective and physiological alcohol craving in response to personalized trauma cues, relative to those high in DT.

Contrary to hypotheses addressing the role of DT in self-medication risk for AUD, DT did not interact with trauma cues to predict elevated subjective craving for alcohol. In other words, low DT did not predict stronger alcohol craving in response to personalized trauma memories, in spite of the trauma narrative eliciting elevations in anxious arousal. DT also did not moderate any of the pathways within an established mediation model of trauma cue-elicited craving (i.e., mediation of trauma cue-craving association by negative affect). Specifically, DT did not moderate an association between negative affect and subjective craving for alcohol (path b), or an association between trauma cues and negative affect (path a). Therefore, even though DT evidences associations with self-reported alcohol coping motives in prior literature (Howell et al., 2010; Marshall-Berenz et al., 2011; Simons & Gaher, 2005; Vujanovic et al., 2011) as well as the current sample, DT likely does not modify self-medication risk for alcohol in young adult trauma-exposed drinkers. This finding does accord with one peripheral substance cue reactivity study in a treatment-seeking sample of individuals with a range of substance use disorders that

similarly did not find an association between DT and trauma cue-elicited craving (Vujanovic et al., 2018). It may be that self-reported coping motives, which capture a range of emotions falling under negative affect, do not correspond well to how individuals react to trauma-specific alterations in negative affect, and therefore future research examining trauma-specific measures of coping motives for alcohol use may be valuable. Alternatively, it is possible that individuals are not reporting accurately on their reasons for drinking, perhaps due to low self-awareness of how they are using alcohol.

Notably, a significant interaction between DT and beverage cue was observed with respect to subjective craving, such that individuals low in DT reported significantly greater craving in response to alcohol cues, as compared to those high in DT. It may be that relative to their high DT counterparts, individuals low in DT are more reactive to alcohol cues in their environment, which in turn may increase their risk for alcohol use problems (Buckner et al., 2007; Duranceau et al., 2014; Marshall-Berenz et al., 2011; Howell et al., 2010; Simons & Gaher, 2005; Vujanovic et al., 2011). Given that alcohol use frequency was included as a covariate in analyses, this finding suggests that there may be an association between DT and alcohol use problems that exists above and beyond the frequency with which these individuals are drinking (i.e., number of “learning trials” in which individuals have the opportunity to develop a conditioned cue response to alcohol). A possible explanation is that individuals low in DT are more sensitive to drug cue conditioning than those high in DT. Given that prior cue reactivity research has found that subjective laboratory craving predicts subsequent alcohol consumption (Cooney et al., 1997; Papachristou et al., 2014), additional longitudinal study is warranted to understand these findings. Inclusion of ecological momentary assessment or similar

methods (Veilleux et al., 2018) may be particularly useful for understanding the role of DT in trauma-exposed individuals' experiences of alcohol craving in the real world.

Other findings worth noting include an observed significant interaction between DT and trauma cue with respect to salivation. However, the magnitude of this interaction effect was quite small, and evaluation of the nature of the interaction indicated that individuals high versus low in DT did not significantly differ on salivatory response to narrative cues (i.e., error bars were overlapping; see Figure 2). In addition, a main effect of DT on craving and salivation, respectively, was not observed, suggesting that DT is not predictive of overall levels of craving and salivation, but rather may be more relevant for understanding craving under certain environmental conditions (e.g., presence of an alcohol cue).

The current findings yield noteworthy theoretical and clinical suggestions. Despite a robust body of cross-sectional survey literature highlighting associations among trauma, DT, and alcohol use outcomes (Buckner et al., 2007; Duranceau et al., 2014; Marshall-Berenz et al., 2011; Howell et al., 2010; Simons & Gaher, 2005; Vujanovic et al., 2011), the present study is the first known investigation of DT in the context of a laboratory trauma and alcohol cue reactivity paradigm. The pattern of findings across baseline measures and cue reactivity trials suggests that among trauma-exposed young adult drinkers, low DT may not exacerbate tendencies toward self-medication use. Instead, it is possible that DT influences alternative processes of AUD risk, such as susceptibility to conditioned craving responses to alcohol. Given that DT is a malleable psychiatric construct, individuals endorsing trauma symptoms and low DT may benefit from clinical interventions designed to increase levels of DT (e.g., Dialectical Behavior Therapy; Linehan, 1993); studies evaluating whether alcohol cue response may be dampened following DT intervention would be useful.

Several study limitations should be considered when interpreting the present findings. First, the current sample was comprised of young adult college students endorsing exposure to interpersonal trauma and regular alcohol use and may not generalize to other samples. The specificity of this sample was important, as it captured a developmentally sensitive period for the onset of trauma-related symptoms and AUD. Second, due to the present study's cross-sectional design, conclusions regarding causation and temporality among study variables cannot be made. Future investigations utilizing longitudinal methods should be employed to elucidate the causal nature of trauma exposure, DT, and patterns of alcohol use, in order to further inform PTSD-AUD self-medication theory and alcohol risk, more broadly. Third, this study only utilized a self-report measure of DT. Given that self-report and behavioral measures of DT perform differently in studies of trauma and substance use (Marshall-Berenz et al., 2010; McHugh et al., 2011; Vujanovic et al., 2018), the present study should be replicated using a behavioral mode of DT measurement.

To conclude, the current study was the first to utilize a laboratory cue reactivity paradigm to examine the influences of DT on trauma and alcohol cue-elicited craving, as well as the first to examine DT in the context of a moderated-mediation model of trauma cue-elicited craving, which represents a laboratory model of self-medication alcohol risk. These preliminary findings offer important insight into self-medication risk among vulnerable young-adult populations. Nonetheless, future studies using EMA and longitudinal methods are needed to further elucidate the nature of AUD risk among trauma-exposed individuals with differing capacities to withstand negative emotional states.

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VI. VITA

NAME: Katherine C. Paltell

EDUCATION: B.S.Ed., Psychology; Speech Pathology & Audiology, University of Virginia, Charlottesville, Virginia, 2017

HONORS: High Honors with Distinction, 2017

Psi Chi International Honor Society in Psychology, 2016

Intermediate Honors

High Distinction Dean's List

Phi Eta Sigma

PUBLICATIONS: **Paltell, K.**, Smith, R., Kansky, J., Cox, C., Amstadter, A., Dick, D., Salvatore, J.*, & Berenz, E.C.* (2020). Posttraumatic stress disorder symptoms, relationship quality, and risky alcohol use among trauma exposed college students. (*Co-last author). *Addictive Behaviors*, 102, 106216.

Bing-Canar, H., McNett, S., Gonzalez, A., Ranney, R., **Paltell, K. C.**, Roberson-Nay, R., Berenz, E. C. (2020). Lifetime trauma exposure, posttraumatic stress disorder, and alcohol dependence as a function of sexual minority status. *Psychological Trauma: Theory, Research, Practice, and Policy*. Advance online publication.

Ranney, R. M., Bing-Canar, H., **Paltell, K. C.**, Tran, J. K., Berenz, E. C., & Vujanovic, A. (*Manuscript under review*). Cardiovascular risk as a moderator of relationships among anxiety sensitivity, distress tolerance, PTSD and depression symptoms among trauma-exposed firefighters.

Paltell, K., Bing-Canar, H., Ranney, R., Tran, J., Berenz, E.*, Vujanovic, A.* (2019). Anxiety sensitivity moderates the effect of posttraumatic stress disorder symptoms on emotion dysregulation among trauma-exposed firefighters. (*Co-last author). *Journal of Psychopathology and Behavioral Assessment*, 41(3), 524-535.

Berenz, E. C., McNett, S., & **Paltell, K.** (2019). Development of comorbid posttraumatic stress disorder and substance use disorders. In Vujanovic, A. A., & Back, S. E. (Eds.). *Posttraumatic stress and substance use disorders: A comprehensive clinical handbook*. New York: Routledge.

CONFERENCE POSTERS AND PRESENTATIONS: **Paltell, K.**, Edalatian Zakeri, S., Berenz, E. (2020). Low distress tolerance predicts greater alcohol cue-elicited craving in trauma-exposed young adult drinkers. Poster presented virtually at the 2020 Research Society on Alcoholism, New Orleans, LA.

H. Bing-Canar, G. Job, **K. Paltell**, and E. Berenz (2020). Evaluation of childhood trauma, age of alcohol initiation, and anhedonia on alcohol problems in young adulthood. Poster presented virtually at the 43rd annual meeting of the Research Society on Alcoholism, New Orleans, LA.

Uribe, V., Job, G. **Paltell, K.**, & Berenz E. (2020). Racial differences in coping motives for alcohol among trauma-exposed young adults. Poster presented virtually at the 2020 Research Society on Alcoholism, New Orleans, LA.

S. Edalatian Zakeri, C. Cox, **K. Paltell**, and E. Berenz (2020). High-intensity binge drinking, enhancement motives, and consequent problems in trauma-exposed young adults. Poster presented virtually at the 2020 Research Society on Alcoholism, New Orleans, LA.

C. Cox, **K. Paltell**, A. Demos, & E. Berenz (2020). Sex differences in trauma and alcohol cue reactivity. Poster presented virtually at the 2020 Research Society on Alcoholism, New Orleans, LA.

Berenz, E.C., Demos, A.P., **Paltell, K.C.**, Bing-Canar, H., Edalatian Zakeri, S., Ranney, R., & Cox, C. M. (2019). Establishing a model of trauma and alcohol cue reactivity for evaluating individual differences in PTSD-AUD risk. In C.M. Cox and E.C. Berenz (Chairs), *Trauma and alcohol reactivity can inform theoretical models of comorbid posttraumatic stress disorder and alcohol use disorder*. Symposium accepted to the 53rd annual meeting of the Association for Behavioral and Cognitive Therapies, Atlanta, GA.

Ranney, R. M., Bing-Canar, H., **Paltell, K. C.**, Tran, J. K., Berenz, E. C., & Vujanovic, A. A. (2019). Cardiovascular risk moderates associations between cognitive-affective risk factors and psychiatric symptoms among trauma-exposed firefighters. Poster presented at the 53rd annual meeting of the Association for Behavioral and Cognitive Therapies, Atlanta, GA.

Paltell, K., Cox, C., Edalatian Zakeri, S., Berenz, E. (2019). Gender differences in the association between posttraumatic stress disorder symptoms and alcohol use problems and PTSD alcohol expectancies in college students with interpersonal trauma exposure. Poster presented at the 4th Annual Center for Alcohol Research in Epigenetics (CARE) Retreat, Chicago, IL.

Bing-Canar, H., Demos, A. P., **Paltell, K. C.**, Job, G. A., Coffey, S. F., & Berenz, E. C. (2019). Examining the influences of major depression and posttraumatic stress disorder on trauma and alcohol cue reactivity. Poster presented at the 4th Annual Center for Alcohol Research in Epigenetics (CARE) Retreat, Chicago, IL.

Berenz, E. C., Demos, A., **Paltell, K. C.**, Bing-Canar, H., Edalatian Zakeri, S., & Ranney, R. M. (2019). Modeling trauma and alcohol cue elicited craving in young adult trauma survivors. Poster presented at the 42nd annual meeting of the Research Society on Alcoholism, Minneapolis, MN.

Paltell, K., Cox, C., Edalatian Zakeri, S., Berenz, E. (2019). Gender differences in the association between posttraumatic stress disorder symptoms and alcohol use problems and PTSD alcohol expectancies in college students with interpersonal trauma exposure. Poster presented at the 2019 Anxiety and Depression Conference, Chicago, IL.

Bing-Canar, H., Demos, A., **Paltell, K.**, Job, G., Coffey, S., & Berenz, E. (2019). Evaluating the influences of major depression and posttraumatic stress disorder on trauma and alcohol cue reactivity. Poster presented at the 39th annual meeting of the Anxiety and Depression Conference, Chicago, IL.

Edalatian Zakeri, S., Demos, A., **Paltell, K.**, Bing-Canar, H., & Berenz, E. (2019). The explanatory role of positive and negative affect in laboratory-observed trauma and alcohol cue-elicited craving. Poster presented at the 39th annual meeting of the Anxiety and Depression Conference, Chicago, IL.

Paltell, K., Kansky, J., Ranney, R., Amstadter, A., Dick, D., Kendler, K., Salvatore, J.*, & Berenz, E.C.* (2018). Posttraumatic Stress Disorder Symptoms, Relationship Quality, and Risky Alcohol Use among Undergraduate University Students. (*Co-last author). Poster presented at the 3rd Annual Center for Alcohol Research in Epigenetics (CARE) Retreat, Chicago, IL.

Cox, C. M., Cho, S. B., Zakeri, S. E., Bing-Canar, H., **Paltell, K. C.**, Langdon, K. J., Dick, D. M., Berenz, E. C. (2018). Interpersonal trauma and smoking trajectories in an undergraduate sample. Poster presented at the Society for Research on Nicotine and Tobacco, San Francisco, CA.

McNett, S., Bing-Canar, H., Ranney, R., **Paltell, K.**, Roberson-Nay, R., & Berenz, E. C. (2018). Associations among lifetime trauma exposure, posttraumatic stress disorder symptoms, and alcohol dependence as a function of sexual minority status. Poster presented at the Sexual and Gender Minority Special Interest Group in the 52nd annual meeting of the Association for Behavioral and Cognitive Therapies, Washington, D.C.

Paltell, K., Kansky, J., Ranney, R., Amstadter, A., Dick, D., Kendler, K., Salvatore, J.*, & Berenz, E.C.* (2018). Posttraumatic Stress Disorder Symptoms, Relationship Quality, and Risky Alcohol Use among Undergraduate University Students. (*Co-last author). Poster presented at the 2018 Anxiety and Depression Conference, Washington, DC.

Paltell, K., Bing-Canar, H., Ranney, R., Berenz, E., Tran, J., Vujanovic, A., (2017). Posttraumatic stress disorder symptoms, anxiety sensitivity, and emotion regulation among firefighters. Poster presented at the 33rd annual meeting of the International Society of Traumatic Stress Studies, Chicago, IL.

PROFESSIONAL AFFILIATIONS:

International Society for Traumatic Stress Studies