

Are trauma memories state-dependent? Intrusive memories following alcohol-involved sexual assault

Anna E. Jaffe , Jessica A. Blayney, Michele Bedard-Gilligan and Debra Kaysen 

Department of Psychiatry and Behavioral Sciences, University of Washington, Seattle, WA, USA

ABSTRACT

Background: Sexual assault (SA) frequently occurs under the influence of alcohol, and is often followed by both drinking and posttraumatic stress symptoms, including intrusive memories. Although many theories attempt to explain the co-occurrence of alcohol use and posttraumatic stress, one possibility not yet considered is that SA memories may be more likely to occur when there is an encoding-retrieval match in alcohol intoxication state.

Objective: The aim of this study was to examine the potential for intrusive memories of SA to be state-dependent, such that intrusive memories for alcohol-involved SA may be more likely to occur in the context of subsequent alcohol intoxication.

Method: Participants were 100 college women (age range = 18 to 24 years; 73% White/Caucasian, 89% heterosexual) with a history of alcohol-involved SA (67%) or other, non-alcohol-involved SA (33%). Participants completed daily questionnaires for 30 days assessing past-day drinking and intrusion symptoms.

Results: A random-intercept, negative binomial multilevel model revealed that, after controlling for overall frequency of drinking and perceived threat during SA, women with a history of alcohol-involved SA reported more severe intrusion symptoms on drinking days than on non-drinking days. No such difference in intrusions was observed for women who were not intoxicated at the time of the assault.

Conclusions: Findings are consistent with the possibility of state-dependent intrusive memories. Additional research is needed to determine whether alcohol intoxication might serve as a discriminative cue preceding intrusive memories of alcohol-involved SA.

Son las memorias del trauma Dependientes del Estado? Recuerdos Intrusivos después de Abuso Sexual con Alcohol

Antecedentes: La agresión sexual (AS) frecuentemente ocurre bajo la influencia de alcohol y suele ir acompañado de síntomas de consumo de alcohol y de estrés postraumático, incluyendo los recuerdos intrusivos. Aunque muchas teorías intentan explicar la co-ocurrencia del consumo de alcohol y estrés postraumático, una posibilidad que aún no se ha considerado es que es más probable que ocurran los recuerdos del AS cuando existe una coincidencia de codificación-recuperación en el estado de intoxicación por alcohol.

Objetivo: El objetivo de este estudio fue examinar la posibilidad de que los recuerdos intrusivos de la AS dependan del estado, de manera tal que los recuerdos intrusivos de la AS con alcohol puedan tener más probabilidad de ocurrir en el contexto de una subsecuente intoxicación con alcohol.

Método: Las participantes fueron 100 mujeres universitarias (rango de edad = 18–24 años; 73% Blancas/caucásicas, 89% heterosexuales) con un historial de AS con alcohol involucrado (67%) u otras AS sin alcohol involucrado (33%). Las participantes completaron cuestionarios diarios por 30 días en los que se evaluaron consumo de alcohol y síntomas intrusivos del día anterior.

Resultados: Un modelo binominal negativo multinivel de intercepción aleatoria reveló que después de controlar la frecuencia general del consumo de alcohol y la amenaza percibida durante la AS, las mujeres con un historial de AS con alcohol involucrado reportaron síntomas intrusivos más severos en los días de consumo de alcohol que en los días sin consumo. No se observó tal diferencia en las intrusiones en las mujeres que no estuvieron intoxicadas con alcohol cuando la AS ocurrió.

Conclusiones: Los hallazgos son consistentes con la posibilidad de recuerdos intrusivos dependiente del estado. Se necesitan investigaciones adicionales para determinar si la intoxicación con alcohol pudiera servir como una señal discriminativa que precede a los recuerdos intrusivos de la AS con alcohol involucrado.

创伤记忆是否有状态依赖？酒精有关性侵犯后的侵入性记忆

背景：性侵犯（SA）经常在酒精的影响下发生，并且通常伴随着饮酒和创伤后应激症状，包括侵入性记忆。虽然许多理论试图解释酒精使用和创伤后应激的共生现象，但尚

ARTICLE HISTORY

Received 30 January 2019

Revised 30 May 2019

Accepted 7 June 2019

KEYWORDS

Incapacitated rape; drug-facilitated sexual assault; peritraumatic intoxication; PTSD; reexperiencing; ecological momentary assessment; daily diary

PALABRAS CLAVE

violación incapacitada; agresión sexual facilitada por las drogas; intoxicación peri-traumática; TEPT; reexperimentación; evaluación ecológica momentánea; registro diario

关键词

无行为能力强奸；毒品性侵犯；围创伤期中毒；创伤后应激障碍；再体验；生态瞬时评估；每日日记法

HIGHLIGHTS

- Sexual assault (SA) often involves alcohol use, and can be followed by heavy drinking and posttraumatic stress, including intrusive memories.
- Daily surveys were completed by 100 college women with a history of SA.
- Drinking alcohol was associated with same-day increases in intrusive memories, but only for women whose SA involved alcohol.
- Results suggest drinking may serve as a trauma reminder for alcohol-involved SA.
- Additional event-level research should consider the potential for state-dependent intrusions.

未考虑的一种可能性是当酒精中毒状态存在编码 - 检索匹配时，SA记忆可能更有可能发生。

目的：本研究的目的是考察关于SA的侵入性记忆存在状态依赖的可能性：即涉及酒精的SA的侵入性记忆更可能在随后的酒精中毒的情况下发生。

方法：被试者为100名大学女性（年龄范围18至24岁；73%白人/高加索人，89%异性恋者），有酒精参与SA（67%）或其他非酒精性SA的病史（33%）。被试者每天完成问卷调查，持续30天，评估过去一天的饮酒和侵入记忆的情况。

结果：随机截距负二项多层次模型显示，在控制SA发生时的总体饮酒频率和感知威胁后，有酒精参与SA的女性报告饮酒日的入侵症状比非饮酒日更严重。对于在被侵犯时没有醉酒的女性中，没有观察到这种侵入性记忆的差异。

结论：结果证明了状态依赖性侵入性记忆的可能性。还需要进一步的研究来确定酒精中毒是否可能成为有酒精参与的SA的侵入性记忆之前的区分线索。

1. Introduction

Sexual assault (SA) is a pervasive problem for women, not just because of its high prevalence (19% of women in the United States; Smith et al., 2017), but also because of the mental health consequences that can result, such as posttraumatic stress disorder (PTSD) and substance abuse or dependence (Dworkin, 2018; Dworkin, Menon, Bystrynski, & Allen, 2017; Rhew, Stappenbeck, Bedard-Gilligan, Hughes, & Kaysen, 2017). Alcohol is commonly involved in SA (Testa & Livingston, 2009), with over half of SA incidents involving drinking by the victim and/or perpetrator (Abbey, Zawacki, Buck, Clinton & McAuslan, 2001). Perpetrators may attempt to get an individual drunk in order to facilitate an assault (Zinzow et al., 2010) or target women whom they perceive as vulnerable due to visible intoxication (Davis, Danube, Stappenbeck, Norris, & George, 2015). Acute alcohol intoxication can in turn impair women's capacity to use effective resistance techniques (Norris et al., 2006). Given the centrality of alcohol in women's SA experiences, further research is needed to better understand how alcohol intoxication at the time of the assault may impact longer-term mental health outcomes.

A small, but growing literature has begun to examine survivor experiences after alcohol-involved SA. These studies suggest that alcohol-involved SA is related to increased risk for revictimization (relative to no SA; Messman-Moore, Ward, & Zerubavel, 2013) and is associated with greater post-assault drinking than non-alcohol-involved SA (Bedard-Gilligan, Kaysen, Desai, & Lee, 2011). Less is known, however, about distress-related outcomes like PTSD. Of the studies conducted, results have been mixed. Compared to non-alcohol-involved SA, some have found that alcohol-involved SA is associated with less severe PTSD symptoms (Peter-Hagene & Ullman, 2018), including fewer initial intrusive symptoms (Kaysen et al., 2010), whereas others indicate no differences (Aakvaag, Strøm, & Thoresen, 2018; Brown, Testa, & Messman-Moore, 2009; Littleton, Grills-Taquechel, & Axsom, 2009; Zinzow et al., 2010). Over time, however, alcohol-

involved assault survivors report more persistent PTSD intrusive symptoms than non-alcohol assault survivors (Kaysen et al., 2010), especially when there is greater intoxication at the time of the SA (Jaffe et al., 2017).

Post-assault distress is often accompanied by heavy drinking, as alcohol use disorders frequently co-occur with PTSD (Kessler, Chiu, Demler, & Walters, 2005). In addition to being consistently positively associated with avoidance and hyperarousal symptoms, alcohol misuse has been linked to greater PTSD-related intrusion symptoms in some, but not all studies (see Debell et al., 2014). Theories that explain this overlap focus on both pre-existing factors and post-trauma reactions as maintaining processes. For example, *shared vulnerability models* (Breslau, Davis, Andreski, Peterson, & Schultz, 1997) posit that there are common underlying biological, affective, or cognitive processes predisposing individuals to develop both alcohol misuse and PTSD. The *high-risk hypothesis* (Chilcoat & Breslau, 1998) proposes that individuals who misuse alcohol are more likely to be exposed to trauma, and thus develop PTSD. The *self-medication hypothesis* (Stewart, Pihl, Conrod, & Dongier, 1998), which is the most widely studied and supported explanation of the overlap, suggests individuals use alcohol after trauma to alleviate distressing symptoms associated with PTSD (Simpson, Stappenbeck, Varra, Moore, & Kaysen, 2012), including intrusive symptoms (Kaysen et al., 2014).

The overlap between alcohol misuse and trauma-related symptoms, including intrusive memories (Johnson, Cottler, O'Leary, & Abdallah, 2010; Taft et al., 2007), can also be viewed in light of alcohol's well-documented effects on memory. When present at the time of encoding, alcohol impairs memory formation (Mintzer, 2007). However, after intoxicated encoding, recollection is enhanced by intoxication at retrieval (see Eich, 1980; Poling & Cross, 1993). For example, female social drinkers who learned a word list while intoxicated subsequently recalled more words when intoxicated (vs. sober) at retrieval (Weingartner, Adefris, Eich, & Murphy, 1976). In this way, alcohol intoxication has been

supported as an internal cue that can facilitate explicit memory retrieval (Duka, Weissenborn, & Dienes, 2001; Weissenborn & Duka, 2000). Termed state-dependent memory, this phenomenon is consistent with broader research demonstrating improved recollection when context (e.g. drug/alcohol state, mood, environment) is matched at encoding and retrieval (Bower & Forgas, 2000; Eich, 1980; Herz, 2004), consistent with Tulving and Thomson's (1973) encoding specificity principle of memory. Although efforts to observe state-dependent effects have revealed mixed findings, substance state-dependent effects have been most consistently demonstrated in studies that ask participants to recall a long-term memory (Eich, 1980; Weingartner, Putnam, George, & Ragan, 1995).

Long-term autobiographical memories, such as trauma memories may be susceptible to alcohol state-dependent effects. That is, the subjective sense of being intoxicated during a trauma may be encoded as a sensory-based trauma memory, and in turn, subsequent intoxication could serve as an internal cue to trigger involuntary recollections of the trauma. Indeed, other forms of sensory-based cues like being touched or a particular posture, or internal sensations like physiological arousal or a feeling of being trapped, can contribute to intrusive reexperiencing of the trauma memory (Ehlers & Clark, 2000). In addition, alcohol might serve as a discriminative stimulus for the conditioned fear response to other environmental cues present during the trauma. In these ways, it is plausible that a trauma encoded in the presence of alcohol could be involuntarily recalled in more detail when subsequently intoxicated, potentially evoking more intrusion-related distress.

In sum, women who experience SA are often under the influence of alcohol during and after the trauma (Abbey et al., 2001; Kaysen, Neighbors, Martell, Fossos, & Larimer, 2006), but it remains unclear how this match in state might affect the occurrence of PTSD-related intrusive memories. Should alcohol use after alcohol-involved-SA increase intrusions, this would be valuable information for clinicians and patients, and could contribute to understanding the high comorbidity between alcohol misuse and PTSD. Therefore, we examined the potential for intrusions to be alcohol state-dependent by examining a sample of college women with a history of SA who completed daily reports of drinking and intrusion symptoms for one month. We hypothesised that women with alcohol-involved SA would report more intrusion symptoms on drinking days than on non-drinking days. We did not expect such differences for participants who experienced non-alcohol-involved SA. Because the distinctiveness of a cue (such as drinking) is important to determine its predictive value for evoking a memory (Goh & Lu, 2012; Nairne, 2002), we also considered frequency of

drinking during the study as a covariate. To further differentiate alcohol involvement during SA from other characteristics of the SA, we also considered perceived threat during SA as a covariate, which has been associated with both assault characteristics (Kaysen, Morris, Rizvi, & Resick, 2005) and subsequent PTSD symptoms in past work (Kaysen, Rosen, Bowman, & Resick, 2010).

2. Method

2.1. Participants and procedures

Participants were drawn from a larger study on trauma exposure (Kaysen et al., 2014) in undergraduate women who reported (1) a history of SA with at least one PTSD intrusive symptom and one PTSD hyperarousal symptom and (2) heavy episodic drinking (4+ drinks in one occasion) at least twice in the past month. Participants received \$20 for an online screening survey, \$25 for an online baseline survey, and up to \$160 for daily diary procedures. The daily diary portion of the study consisted of a one-on-one training session followed by 30 days of morning and evening 5-minute surveys on a study personal digital assistant. Participants selected a 2-hour block in the morning and evening to complete their daily surveys, with an alarm set on the personal digital assistant as a survey reminder. Daily PTSD symptoms and past-day alcohol use were assessed only in the morning surveys. All procedures were approved by the University's Institutional Review Board.

A total of 108 women who identified an index SA since the age of 14 participated. Those who did not respond ($n = 3$) or were not sure ($n = 4$) whether they were under the influence of alcohol at the time of this index SA were excluded from analyses. An additional 1 participant was excluded for missing data on perceived threat during the SA. The final sample therefore included 100 women, 67 of whom reported an alcohol-involved SA and 33 who reported a non-alcohol-involved SA. Participants were 18 to 24 years old ($M = 20.10$, $SD = 1.22$). The sample consisted of 73% White/Caucasian, 8% Asian/Pacific Islander, 2% Black/African American, 1.0% Native American/American Indian, 12% multi-racial, and 3% other-race students (1% did not indicate a racial identity). Regarding ethnicity, 6% identified as Hispanic/Latina. In addition, 89% identified as heterosexual.

2.2. Screening measures

2.2.1. Sexual assault history

SA in adolescence or adulthood (since age 14) was assessed via the Sexual Experiences Survey (SES; Koss & Gidycz, 1985; Koss & Oros, 1982). Unwanted sexual experiences were defined as '*unwanted oral-genital*

contact, vaginal/anal intercourse, and/or vaginal/anal penetration by objects' (response options: 0 = no, 1 = yes). Participants were considered to have a history of SA if they responded 'yes' to any item on the SES.

2.3. Baseline measures

2.3.1. Alcohol-involved sexual assault

Focusing on the 'most upsetting' or index SA experience, participants were asked whether they 'were under the influence of alcohol or drugs at the time of the assault.' Response options were 0 = no, 1 = yes, and 2 = not sure (as detailed above, the four participants who responded 'not sure' were excluded from analyses). Participants who responded 'yes' were asked to specify which of nine substance(s) they used (e.g., alcohol, marijuana, amphetamines, etc.), and if alcohol was endorsed, how many drinks they consumed prior to the assault. Whether individuals were under the influence of alcohol at the time of the SA was coded as 0 = non-alcohol-involved SA or 1 = alcohol-involved SA.

2.3.2. Perceived threat

Regarding the index SA, participants were also asked, 'During the worst unwanted sexual experience, did you think about being killed or seriously injured?' with response options ranging from 0 = no, not at all to 4 = I thought about it all the time. In addition, participants were asked, 'During the incident, how certain were you that you were going to be killed?' with response options ranging from 0 = I was completely certain that I was not going to be killed to 4 = I was completely certain that I was going to be killed. Consistent with past research on perceived threat (Kaysen et al., 2005, 2010), these two items were summed to create a total score with a possible range from 0 to 8.

2.4. Daily diary measures

2.4.1. Alcohol use

After viewing a standard drink chart, participants were asked to report the number of drinks they consumed in the last 24 hours (open ended response). For this study, responses were dichotomized to represent whether any drinks were consumed on a given day. Percent of drinking days was computed out of the total number of diaries completed.

2.4.2. Intrusion symptoms

The PTSD Checklist – Specific version (PCL-S; Weathers, Litz, Herman, Huska, & Keane, 1993) was modified for daily use to assess symptoms related to the index sexual assault. Participants were asked how much each symptom bothered them in the past 24 hours on a scale from 0 = not at all to 4 = extremely.

Five items corresponding to the intrusion/reexperiencing symptom cluster of DSM-IV PTSD were summed. Acceptable internal reliability was observed in this sample ($\alpha = 0.83$).

2.5. Data analysis

To determine the amount of between- and within-person variance in intrusion symptoms, an intraclass correlation was computed via an empty-means, random intercept model. Intrusion symptoms were then modeled in SAS PROC GLIMMIX using maximum likelihood estimation to retain participants who did not complete all daily diaries. Although intrusion symptoms were measured using a sum score, this variable was not normally distributed. Therefore, to represent this positively skewed distribution of non-negative integers, we utilised a count distribution and a log link to keep predicted values above 0. A Poisson distribution (in which the variance is assumed to equal the mean) was compared to a negative binomial distribution (which includes a dispersion or scale parameter allowing the variance to differ from the mean) using a deviance difference test. Intrusion symptoms were expected to show within-person fluctuation, but no systematic change over the course of the 30-day monitoring period. Therefore, models with a random intercept but no random or fixed effects of time were considered. Fixed effects were specified as follows:

$$\text{Level 1 : } \text{Intrusions}_{ti} = \beta_{0i} + \beta_{1i}(\text{Drinking Day})_{ti} + e_i$$

$$\begin{aligned} \text{Level 2 : } \beta_{0i} = & \gamma_{00} + \gamma_{01}(\text{Percent Drinking Days}_i) \\ & + \gamma_{02}(\text{Perceived Threat During SA}_i) \\ & + \gamma_{03}(\text{Alcohol During SA}_i) + U_{0i} \end{aligned}$$

$$\beta_{1i} = \gamma_{10} + \gamma_{11}(\text{Alcohol During SA}_i)$$

Specifically, between-person fixed effects were examined for percent of drinking days during the study, perceived threat during SA, and alcohol involvement during SA. Any drinking in the past day was also included as a within-person main effect. The cross-level interaction between alcohol involvement during SA and past-day drinking was included and pairwise comparisons were examined, regardless of the significance of the omnibus test (Howell, 2013).

3. Results

3.1. Descriptive statistics

Among the 100 participants, 67% reported they were under the influence of alcohol at the time of their index SA. These participants reported consuming between 1 and 20 drinks ($M = 6.84$, $SD = 3.76$) at

the time of assault. In addition, 13% of all participants reported being under the influence of drug(s) in addition to alcohol at the time of the SA, such as marijuana ($n = 7$), marijuana in combination with hallucinogens, barbiturates, cocaine and/or other drugs ($n = 4$), or cocaine and/or amphetamines ($n = 2$). No participants reported other drug use in the absence of alcohol use.

The average participant completed 20.06 daily diaries ($SD = 7.40$; range = 1 to 29). Diary completion did not differ significantly between those with alcohol-involved and non-alcohol-involved SA, $t(98) = 1.56$, $p = .121$, and was not associated with average intrusion severity, $r = .11$, $p = .257$, or percent drinking days, $r = -.05$, $p = .609$. Participants reported drinking alcohol on 0% to 90.9% of the days that diaries were completed ($M = 29.9\%$, $SD = 21.1\%$). Percentage of drinking days did not significantly differ between participants with an alcohol-involved SA ($M = 32.4\%$, $SD = 22.4\%$) and those with non-alcohol-involved SA ($M = 24.8\%$, $SD = 17.5\%$), $t(98) = -1.71$, $p = .090$.

With regard to perceived threat, participants with an alcohol-involved SA ($M = 0.67$, $SD = 1.38$) did not significantly differ from participants with a non-alcohol-involved SA ($M = 0.60$, $SD = 1.30$), $t(98) = 0.25$, $p = .806$. However, regardless of alcohol involvement, greater perceived threat during the SA was associated with more severe average intrusion symptoms, $r = .31$, $p = .002$, and greater percentage of drinking days during the study, $r = .20$, $p = .047$.

3.2. Prediction of intrusion symptoms

The intraclass correlation revealed that 50.4% of the variance in intrusion symptoms was due to between-person mean differences, and the remaining 49.6% was due to within-person variation. A negative binomial count distribution fit significantly better than a Poisson distribution, $-2\Delta LL(1) = 741.45$, $p < .001$, and was therefore retained. Model results revealed a significant interaction between alcohol-involved SA and drinking day, $B = 0.30$, $SE = 0.15$, $p = .046$, after controlling for percentage of drinking days and perceived threat during SA (see Table 1). As can be seen in Table 2, pairwise comparisons revealed that women whose index SA involved alcohol reported significantly more severe intrusion symptoms on drinking days than non-drinking days, $t(91) = 3.09$, $p = .003$, after controlling for

Table 1. Results of Negative Binomial Multilevel Model Predicting Intrusion Severity.

	B	SE	p
Model for the means			
γ_{00} Intercept	-0.30	0.36	.413
γ_{10} Drinking Day	-0.02	0.12	.885
γ_{01} Percent Days Drinking	-0.48	0.85	.574
γ_{02} Perceived Threat during SA	0.39	0.13	.003**
γ_{03} Alcohol-Involved SA	-0.25	0.37	.503
γ_{11} Alcohol-Involved SA x Drinking Day	0.30	0.15	.046*
Model for the variance			
$\tau^2_{U_0}$ Random intercept variance	2.63	0.47	
Scale	0.74	0.06	

SE = standard error; SA = sexual assault. * $p < .05$. ** $p < .01$.

between-person differences in percentage of drinking days and perceived threat during SA. There was no such effect of drinking on intrusion symptoms for those whose SA did not involve alcohol, $t(91) = -0.15$, $p = .885$. Moreover, there were no significant differences in intrusion symptoms between alcohol-involved and non-alcohol-involved SA during drinking days, $t(91) = 0.13$, $p = .898$, or non-drinking days, $t(91) = -0.67$, $p = .503$. Although pairwise comparisons involved contrasting model estimates in log units, exponentiated estimates are represented in Figure 1 to more clearly show model-predicted values on the original scale of the intrusion severity sum score.

4. Discussion

This study is the first to consider potential state-dependent effects of alcohol on intrusive SA trauma memories. Consistent with expectations, college women with a history of alcohol-involved SA reported more severe intrusion symptoms on drinking days than on non-drinking days, whereas no such difference was found for non-alcohol-involved SA after controlling for overall drinking frequency and perceived threat during SA. Among alcohol-involved SA survivors, the experience of feeling intoxicated at the time of the assault may have been encoded as a sensory component of the trauma memory. Subsequent intoxication may have served as a sensory-based cue, evoking involuntary memories of the trauma. Because cues for trauma-related memories often go unidentified, the memory may be experienced as spontaneous, distressing, and intrusive (Ehlers & Clark, 2000). In addition, when there is a match (vs. no match) in alcohol state between encoding and retrieval, more details of the trauma memory might be available for recall, and therefore,

Table 2. Simple Effects Comparisons for Intrusion Severity.

	Non-Drinking Day			Drinking Day			$t(df = 91)$	p
	B	SE	exp(B)	B	SE	exp(B)		
Alcohol-Involved SA	-0.30	0.22	0.74	-0.02	0.23	0.98	3.09	.003**
Non-Alcohol-Involved SA	-0.05	0.30	0.95	-0.07	0.31	0.94	-0.15	.885

SE = standard error; SA = sexual assault. For all estimates, percent of drinking days was held constant at 0.30 and perceived threat was held constant at 1. Estimates (B and SE) are in log units. Exp(B) represented predicted intrusion severity scores plotted in Figure 1. ** $p < .01$.

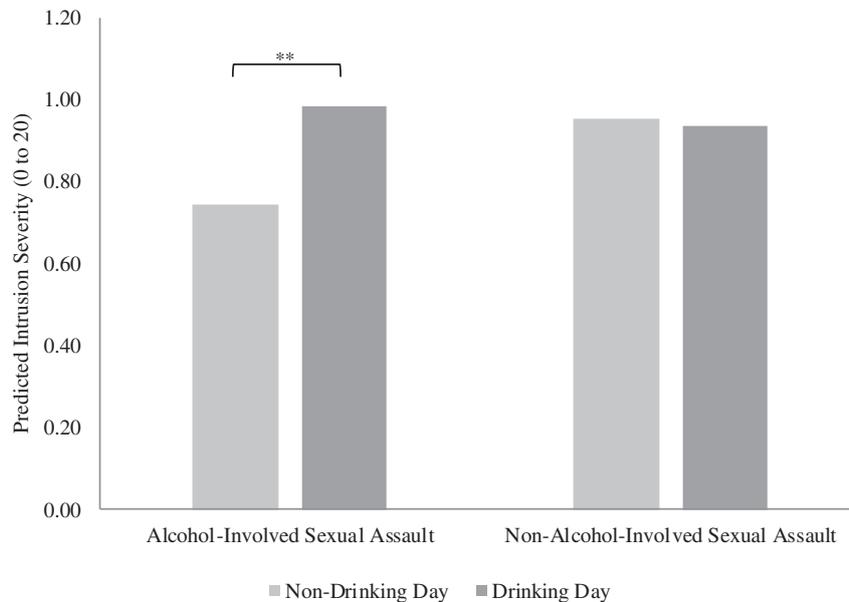


Figure 1. Simple effects comparisons for intrusion severity holding percentage drinking days constant at 0.30 and perceived threat constant at 1. $**p < .01$.

involuntary intrusive memories may be experienced as particularly detailed, current (i.e. with a greater sense of ‘nowness’), and distressing. It is also possible that drinking episodes may involve exposure to environmental cues (e.g. a bar or party, the smell of a certain drink, witnessing peers’ intoxicated behavior) that are similar to the original alcohol-involved SA, which may allow for context-dependent memory access or serve as cues for intrusive memories. Additional research is needed to determine whether intrusions might be differentially affected by internal subjective cues of intoxication and external environmental cues of drinking context.

These findings also shed light on the overall associations between alcohol-involved SA and subsequent intrusive memories. Prior studies examining alcohol involvement during SA and subsequent PTSD-related intrusions have revealed mixed findings (Aakvaag et al., 2018; Brown et al., 2009; Jaffe et al., 2017; Kaysen et al., 2010; Littleton et al., 2009; Peter-Hagene & Ullman, 2018; Zinzow et al., 2010), and we found no difference by SA type in overall intrusion symptoms. However, intrusions after alcohol-involved SA depended on daily consumption of alcohol in our study, which suggests that post-SA alcohol use may be an important factor not considered in previous work. Frequency of post-SA alcohol use, and therefore exposure to alcohol-related cues, is likely to vary between previously studied samples and might shed light on discrepant findings. We encourage future studies to examine post-SA drinking as a potential moderator of the association between peritraumatic alcohol use and subsequent intrusion symptoms.

In this study, we found no difference in intrusions between drinking and non-drinking days for participants with non-alcohol-involved SA. Although true state-dependent effects would suggest that a sober

state at encoding of the trauma would also be followed by better recollection while sober (vs. intoxicated) at retrieval, completeness of voluntary recall for the trauma memory was not assessed in this study. Instead, we assessed the occurrence of intrusive or involuntary memories, which likely reflects both the availability of any complete or fragmentary memory and the presence of cue-driven retrieval. A sober state was not expected to be a distinctive cue specific to the trauma, and therefore would not be expected to functionally improve retrieval (Nairne, 2002).

Although we focused on the potential for state-dependent intrusions in this study, findings could also be interpreted within a self-medication framework. Due to the daily nature of the assessments in our study, we were unable to determine whether drinking or intrusions occurred first on a given day. We focused on intrusion symptoms as our outcome, but it is plausible that individuals who experienced an alcohol-involved SA were more likely to drink in response to having more intrusions, consistent with the self-medication model (Stewart et al., 1998). Indeed, experimental studies have shown that trauma-related cues, including exposure to the trauma memory itself, elicit alcohol cravings in individuals with PTSD and alcohol use disorder (e.g. Coffey et al., 2010). Those who report alcohol-involved SA are also particularly likely to report high rates of drinking both before and after the SA (Kaysen et al., 2006), and therefore, may be especially likely to turn to alcohol as a means of coping with trauma-related distress. Future studies with more time-sensitive assessments of drinking and intrusions are needed to determine the temporal ordering of drinking and intrusions in survivors of alcohol-

involved SA. Still, self-medication models and the potential for state-dependent intrusions should not be seen as competing hypotheses, but instead may work in tandem. For example, intrusions for alcohol-involved SA may occur more frequently in the context of alcohol use, which may then lead to increased distress and drinking to cope. We recommend the examination of these reciprocal associations within drinking episodes.

4.1. Limitations and future directions

This study utilised archival data collected as part of a larger study, and as such, there are limitations to the conclusions that can be drawn. First, we only considered the presence or absence of alcohol during the assault because blood alcohol concentration could not be reliably estimated with the available data (duration of the pre-SA drinking episode and weight at the time of the SA were not assessed). However, prior research has indicated that alcohol state-dependent effects have been most consistently demonstrated for moderate doses; low doses may not be sufficient to observe an effect and high doses may severely impair memory encoding (Eich, 1980). We recommend considering dose in future examinations of post-SA drinking on intrusions. Second, we only considered alcohol effects in this study, although a small subset of participants ($n = 13$) also endorsed marijuana or other drugs in addition to alcohol at the time of SA. It is possible that the presence of other drugs at the time of encoding, and potentially at the time of retrieval, could complicate state-dependent effects. Given the low base rates of other drugs during SA in this study, a larger sample is needed to consider this possibility. Relatedly, although we only had data on participants' alcohol use prior to the assault, alcohol-involved SA commonly involve alcohol use by both the victim and perpetrator (e.g. Aakvaag et al., 2018). Future work is therefore needed to disentangle whether perpetrator alcohol use might also contribute to post-assault intrusions when in drinking contexts, perhaps because being around other intoxicated individuals could serve as a reminder of the perpetrator. In addition, sexual revictimization is common (Walker, Freud, Ellis, Fraine, & Wilson, 2019) and although we did not assess the number of adolescent/adulthood SA experiences, or alcohol-involvement for non-index assaults, such event-level assessments for each SA would allow for more specificity in future studies of SA-related intrusions. Similarly, we included perceived threat as a proxy for SA severity, but incorporating more event-level questions would allow for more direct consideration of SA characteristics when testing the unique effect of alcohol intoxication on intrusions. Moreover, future studies should examine whether patterns are specific to

intrusions or related to general increases in PTSD symptoms in settings associated with the SA. Finally, more detailed assessment (e.g. intrusion diaries; Holmes, Brewin, & Hennessy, 2004) would help to clarify whether intoxication affects the occurrence of intrusive memories or resulting distress.

4.2. Conclusions

In sum, this study was the first to examine whether alcohol use can act as a trauma-related cue for intrusive memories of SA on a given day using a daily diary methodology. Although prior event-level studies have found daily relationships between increases in same-day PTSD and drinking (Gaher et al., 2014; Kaysen et al., 2014), none have tested whether drinking itself can provide a contextual cue around the traumatic event. Our results suggest that for women whose worst SA involved alcohol, drinking on a given day was associated with same day increases in intrusive symptoms of PTSD. This pattern was not seen for women whose index SA did not involve alcohol. Although replication and additional research is needed, these results have important implications for interventions aimed at addressing alcohol use and PTSD for women who have experienced alcohol-involved SA. Results point to the importance of working with survivors to anticipate how alcohol use may exacerbate, instead of mitigate PTSD symptoms in cases where alcohol was part of the original trauma memory. Therapists may also wish to discuss how using alcohol to manage these symptoms may lead to downstream escalations in alcohol use. Intervening to build up situational coping skills may help prevent this escalation. Just-in-time interventions that reach survivors in distressing situations may be a useful direction for future research.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This research was funded in part by grants from the National Institute of Alcohol Abuse and Alcoholism R21AA016211 (PI: Kaysen) and T32AA007455 (PI: Larimer). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institute on Alcohol Abuse and Alcoholism.

ORCID

Anna E. Jaffe  <http://orcid.org/0000-0001-8679-7564>
Debra Kaysen  <http://orcid.org/0000-0001-7961-2787>

References

- Aakvaag, H. F., Strøm, I. F., & Thoresen, S. (2018). But were you drunk? Intoxication during sexual assault in Norway. *European Journal of Psychotraumatology*, 9(1), 1539059.
- Abbey, A., Zawacki, T., Buck, P. O., Clinton, A. M., & McAuslan, P. (2001). Alcohol and sexual assault. *Alcohol Research & Health*, 25(1), 43–51.
- Bedard-Gilligan, M., Kaysen, D., Desai, S., & Lee, C. M. (2011). Alcohol-involved assault: Associations with post-trauma alcohol use, consequences, and expectancies. *Addictive Behaviors*, 36, 1076–1082.
- Bower, G. H., & Forgas, J. P. (2000). Affect, memory, and social cognition. In E. Eich, J. F. Kihlstrom, G. H. Bower, J. P. Forgas, & P. M. Niedenthal (Eds.), *Cognition and emotion* (pp. 87–168). New York: Oxford University Press.
- Breslau, N., Davis, G. C., Andreski, P., Peterson, E. L., & Schultz, L. R. (1997). Sex differences in posttraumatic stress disorder. *Archives of General Psychiatry*, 54, 1044–1048.
- Brown, A. L., Testa, M., & Messman-Moore, T. L. (2009). Psychological consequences of sexual victimization resulting from force, incapacitation, or verbal coercion. *Violence Against Women*, 15, 898–919.
- Chilcoat, H. D., & Breslau, N. (1998). Posttraumatic stress disorder and drug disorders: Testing causal pathways. *Archives of General Psychiatry*, 55, 913–917.
- Coffey, S. F., Schumacher, J. A., Stasiewicz, P. R., Henslee, A. M., Baillie, L. E., & Landy, N. (2010). Craving and physiological reactivity to trauma and alcohol cues in posttraumatic stress disorder and alcohol dependence. *Experimental and Clinical Psychopharmacology*, 18, 340–349.
- Davis, K. C., Danube, C. L., Stappenbeck, C. A., Norris, J., & George, W. H. (2015). Background predictors and event-specific characteristics of sexual aggression incidents: The roles of alcohol and other factors. *Violence Against Women*, 21, 997–1017.
- Debell, F., Fear, N. T., Head, M., Batt-Rawden, S., Greenberg, N., Wessely, S., & Goodwin, L. (2014). A systematic review of the comorbidity between PTSD and alcohol misuse. *Social Psychiatry and Psychiatric Epidemiology: The International Journal for Research in Social and Genetic Epidemiology and Mental Health Services*, 49, 1401–1425.
- Duka, T., Weissenborn, R., & Dienes, Z. (2001). State-dependent effects of alcohol on recollective experience, familiarity and awareness on memories. *Psychopharmacology*, 153, 295–306.
- Dworkin, E. R. (2018). Risk for mental disorders associated with sexual assault: A meta-analysis. *Trauma, Violence, & Abuse*. Advanced online publication. doi:10.1177/1524838018813198
- Dworkin, E. R., Menon, S. V., Bystrynski, J., & Allen, N. E. (2017). Sexual assault victimization and psychopathology: A review and meta-analysis. *Clinical Psychology Review*, 56, 65–81.
- Ehlers, A., & Clark, D. M. (2000). A cognitive model of posttraumatic stress disorder. *Behaviour Research and Therapy*, 38, 319–345.
- Eich, J. E. (1980). The cue-dependent nature of state-dependent retrieval. *Memory & Cognition*, 8, 157–173.
- Gaher, R. M., Simons, J. S., Hahn, A. M., Hofman, N. L., Hansen, J., & Buchkoski, J. (2014). An experience sampling study of PTSD and alcohol-related problems. *Psychology of Addictive Behaviors*, 28, 1013–1025.
- Goh, W. D., & Lu, S. H. X. (2012). Testing the myth of the encoding–Retrieval match. *Memory & Cognition*, 40, 28–39.
- Herz, R. S. (2004). A naturalistic analysis of autobiographical memories triggered by olfactory visual and auditory stimuli. *Chemical Senses*, 29, 217–224.
- Holmes, E. A., Brewin, C. R., & Hennessy, R. G. (2004). Trauma films, information processing, and intrusive memory development. *Journal of Experimental Psychology: General*, 133, 3–22.
- Howell, D. C. (2013). *Statistical methods for psychology* (8th ed.). Belmont, CA: Wadsworth, Cengage Learning.
- Jaffe, A. E., Steel, A. L., DiLillo, D., Hoffman, L., Gratz, K. L., & Messman-Moore, T. L. (2017). Victim alcohol intoxication during a sexual assault: Relations with subsequent PTSD symptoms. *Violence and Victims*, 32, 642–657.
- Johnson, S. D., Cottler, L. B., O’Leary, C. C., & Abdallah, A. B. (2010). The association of trauma and PTSD with the substance use profiles of alcohol- and cocaine-dependent out-of-treatment women. *The American Journal on Addictions*, 19, 490–495.
- Kaysen, D., Atkins, D. C., Simpson, T. L., Stappenbeck, C. A., Blayney, J. A., Lee, C. M., & Larimer, M. E. (2014). Proximal relationships between PTSD symptoms and drinking among female college students: Results from a daily monitoring study. *Psychology of Addictive Behaviors*, 28, 62–73.
- Kaysen, D., Morris, M. K., Rizvi, S. L., & Resick, P. A. (2005). Peritraumatic responses and their relationship to perceptions of threat in female crime victims. *Violence Against Women*, 11, 1515–1535.
- Kaysen, D., Neighbors, C., Martell, J., Fossos, N., & Larimer, M. E. (2006). Incapacitated rape and alcohol use: A prospective analysis. *Addictive Behaviors*, 31, 1820–1832.
- Kaysen, D., Rosen, G., Bowman, M., & Resick, P. A. (2010). Duration of exposure and the dose-response model of PTSD. *Journal of Interpersonal Violence*, 25, 63–74.
- Kaysen, D. L., Lindgren, K. P., Lee, C. M., Lewis, M. A., Fossos, N., & Atkins, D. C. (2010). Alcohol-involved assault and the course of PTSD in female crime victims. *Journal of Traumatic Stress*, 23, 523–527.
- Kessler, R. C., Chiu, W. T., Demler, O., & Walters, E. E. (2005). Prevalence, severity, and comorbidity of 12-month DSM-IV disorders in the National Comorbidity Survey Replication. *Archives of General Psychiatry*, 62, 617–627.
- Koss, M. P., & Gidycz, C. A. (1985). Sexual experiences survey: Reliability and validity. *Journal of Consulting and Clinical Psychology*, 53, 422–423.
- Koss, M. P., & Oros, C. J. (1982). Sexual experiences survey: A research instrument investigating sexual aggression and victimization. *Journal of Consulting and Clinical Psychology*, 50, 455–457.
- Littleton, H., Grills-Tauchel, A., & Axsom, D. (2009). Impaired and incapacitated rape victims: Assault characteristics and post-assault experiences. *Violence and Victims*, 24, 439–457.
- Messman-Moore, T. L., Ward, R. M., & Zerubavel, N. (2013). The role of substance use and emotion dysregulation in predicting risk for incapacitated sexual revictimization in women: Results of a prospective investigation. *Psychology of Addictive Behaviors*, 27, 125–132.

- Mintzer, M. Z. (2007). The acute effects of alcohol on memory: A review of laboratory studies in healthy adults. *International Journal on Disability and Human Development*, 6, 397–403.
- Nairne, J. S. (2002). The myth of the encoding-retrieval match. *Memory*, 10, 389–395.
- Norris, J., George, W. H., Stoner, S. A., Masters, N. T., Zawacki, T., & Davis, K. C. (2006). Women's responses to sexual aggression: The effects of childhood trauma, alcohol, and prior relationship. *Experimental and Clinical Psychopharmacology*, 14, 402–411.
- Peter-Hagene, L. C., & Ullman, S. E. (2018). Longitudinal effects of sexual assault victims' drinking and self-blame on posttraumatic stress disorder. *Journal of Interpersonal Violence*, 33, 83–93.
- Poling, A., & Cross, J. (1993). State-dependent learning. In J. P. Huston (Ed.), *Methods in behavioral pharmacology* (pp. 245–256). Amsterdam: Elsevier.
- Rhew, I. C., Stappenbeck, C. A., Bedard-Gilligan, M., Hughes, T., & Kaysen, D. (2017). Effects of sexual assault on alcohol use and consequences among young adult sexual minority women. *Journal of Consulting and Clinical Psychology*, 85, 424–433.
- Simpson, T. L., Stappenbeck, C. A., Varra, A. A., Moore, S. A., & Kaysen, D. (2012). Symptoms of post-traumatic stress predict craving among alcohol treatment seekers: Results of a daily monitoring study. *Psychology of Addictive Behaviors*, 26, 724–733.
- Smith, S. G., Chen, J., Basile, K. C., Gilbert, L. K., Merrick, M. T., Patel, N., ... Jain, A. (2017). *The National Intimate Partner and Sexual Violence Survey (NISVS): 2010–2012 state report*. Atlanta, GA: National Center for Injury Prevention and Control, Centers for Disease Control and Prevention.
- Stewart, S. H., Pihl, R. O., Conrod, P. J., & Dongier, M. (1998). Functional associations among trauma, PTSD and substance-related disorders. *Addictive Behaviors*, 23, 797–812.
- Taft, C. T., Kaloupek, D. G., Schumm, J. A., Marshall, A. D., Panuzio, J., King, D. W., & Keane, T. M. (2007). Posttraumatic stress disorder symptoms, physiological reactivity, alcohol problems, and aggression among military veterans. *Journal of Abnormal Psychology*, 116, 498–507.
- Testa, M., & Livingston, J. A. (2009). Alcohol consumption and women's vulnerability to sexual victimization: Can reducing women's drinking prevent rape? *Substance Use and Misuse*, 44, 1349–1376.
- Tulving, E., & Thomson, D. M. (1973). Encoding specificity and retrieval processes in episodic memory. *Psychological Review*, 80, 352–373.
- Walker, H. E., Freud, J. S., Ellis, R. A., Fraine, S. M., & Wilson, L. C. (2019). The prevalence of sexual revictimization: A meta-analytic review. *Trauma, Violence & Abuse*, 20, 67–80.
- Weathers, F. W., Litz, B. T., Herman, D. S., Huska, J. A., & Keane, T. M. (1993, October). *The PTSD checklist: Reliability, validity, and diagnostic utility*. Paper presented at the annual meeting of the International Society for Traumatic Stress Studies, San Antonio, TX.
- Weingartner, H., Adefris, W., Eich, J. E., & Murphy, D. L. (1976). Encoding-imagery specificity in alcohol state-dependent learning. *Journal of Experimental Psychology: Human Learning and Memory*, 2, 83–87.
- Weingartner, H. J., Putnam, F., George, D. T., & Ragan, P. (1995). Drug state-dependent autobiographical knowledge. *Experimental and Clinical Psychopharmacology*, 3, 304–307.
- Weissenborn, R., & Duka, T. (2000). State-dependent effects of alcohol on explicit memory: The role of semantic associations. *Psychopharmacology*, 149, 98–106.
- Zinzow, H. M., Resnick, H. S., McCauley, J. L., Amstadter, A. B., Ruggiero, K. J., & Kilpatrick, D. G. (2010). The role of rape tactics in risk for posttraumatic stress disorder and major depression: Results from a national sample of college women. *Depression and Anxiety*, 27, 708–715.