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ORIGINAL ARTICLE

Post-event Processing and Alcohol Intoxication: The Moderating Role of Social Anxiety

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Abstract
To resolve the mixed findings on the link between social anxiety (SA) and alcohol use, studies have examined the role of post-event processing (PEP), i.e., negative thinking about past social events. In a sample of 18–30 year olds (82% female) high ($n=40$) and low ($n=49$) in SA, the current 21-day study assessed the effect of PEP after social drinking events on subjective intoxication at the next social event. The moderating role of SA severity was tested. Compared to the low SA group, the high SA group reported overall more PEP but similar intoxication levels. Multilevel models supported a SA by PEP interactive effect on next-event intoxication, but for the high SA group only. Conditioned slopes revealed that within the high SA group, at -1 *SD* elevated PEP predicted increased next-event intoxication. Thus, for those 'moderate/high' in SA, PEP after social drinking may increase risk for alcohol misuse.

Keywords Post-event processing · Social anxiety · Alcohol use · Intoxication

Introduction

Social anxiety (SA) and alcohol use disorder are two of the most common psychological disorders (Kessler et al. 2005), and they often co-occur (Grant et al. 2005; Morris et al. 2005; Stewart and Conrod 2008). Interventions can be informed by understanding the mechanistic processes that link SA to problem drinking. The aim of the current study was to examine specific factors that might influence the risk trajectory during young adulthood (e.g., university students), a time when individuals are frequently exposed to social situations where alcohol use is the norm (Schry and White 2013).

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Social Anxiety and Alcohol Use

SA is characterized by marked fear of being negatively evaluated by others in social situations (American Psychiatric Association 2013; Schultz and Heimberg 2008). Individuals with SA often fear appearing nervous in front of others (e.g., Morris et al. 2005), and interpret ambiguous social cues as negative (e.g., Alden et al. 2008; Amir et al. 2005). Individuals with SA are also found to repeatedly think about and negatively reconstruct their behaviour during recent social events (Brozovich and Heimberg 2008; Clark and Wells 1995). Those high in SA tend to avoid social events or endure them with distress (e.g., Clark 2005; Hofmann 2007).

According to the self-medication hypothesis (Khantzian 1985) and tension-reduction theory (Conger 1951), individuals with SA may use alcohol for its anxiolytic effects, thus allowing them to tolerate otherwise emotionally distressing social events (e.g., Abrams et al. 2001). Consistent with this, some evidence supports SA as a positive correlate of alcohol use as a way to cope in social situations (e.g., Buckner and Heimberg 2010; Thomas et al. 2003). There is also research demonstrating a high rate of comorbidity between SA and alcohol use disorder (e.g., Buckner et al. 2006; Buckner and Schmidt 2009; Schneier et al. 2010). Additionally, studies have shown that when participants high in SA are exposed to an experimentally-induced

social stressor, they drink more than those in a control/neutral condition (e.g., Abrams et al. 2002), and that drinking alcohol leads to reduced anxiety (e.g., Abrams et al. 2001). However, other studies have found SA to be a negative correlate of alcohol use (e.g., Eggleston et al. 2004; Ham and Hope 2006; Stewart et al. 2006). Similarly, experimental work found that participants (including those high in SA) consumed less alcohol during a stressful social situation when they were given negative as opposed to positive evaluations (Holroyd 1978). Finally, several studies found no association between SA and alcohol use (e.g., Gilles et al. 2006; Ham et al. 2009; LaBrie et al. 2008). What can be garnered from the extensive SA and drinking literature, is that empirical evidence generally supports a positive link between SA and alcohol-related *problems* (e.g., Buckner et al. 2006, 2008; Gilles et al. 2006), but the broader link between SA and alcohol use (i.e., frequency and quantity of alcohol consumption) remains less clear.

One possible explanation for the inconsistent findings is that the majority of studies considered a linear association between SA and alcohol use. A study by Crum and Pratt (2001), which examined the risk of developing drinking problems across individuals with varying levels of SA (i.e., clinical, subclinical or none), suggests that considering SA solely on a continuum may mask findings. Specifically, they found that those in the subclinical SA group, characterized by an irrational fear of social situations without significant impairment or avoidance, were twice as likely to develop alcohol use problems a decade later compared to those in the clinical-level SA disorder group and those in the non-SA group. Thus, a specific subset of individuals high in SA appeared to be at risk of developing alcohol use problems. Moving forward, this work suggests that we should consider not only high and low SA groups when investigating alcohol use risk, but also consider how differences within these groups align with drinking risk.

Another potential explanation for the mixed findings is that the association between SA and alcohol use is complex, even within person. On the one hand, those high in SA may be inclined to drink for anxiolytic effects, but on the other hand, their fear of negative alcohol-related social consequences, such as embarrassing themselves when intoxicated, could deter them. As demonstrated in lab-based studies (e.g., Abrams et al. 2002), inducing SA increases drinking. However, it would also make sense that regret and anxiety the morning after should curtail future drinking. Indeed, Cooke, Sniehotta, and Schüz (2007) found that anticipated regret after binge-drinking was associated with reduced binge-drinking intentions and behaviour. Understanding the complexity of this risk pathway necessitates a prospective investigation in which differences within and across levels of SA are considered, and potential mechanisms are examined across sequential social events.

Post-event Processing

Post-event processing (PEP) involves negatively biased thinking about one's performance during past social events (Abbott and Rapee 2004; Kocovski et al. 2005). PEP occurs immediately after social events and in anticipation of the next event. As a result of PEP, individuals' negative impressions of themselves and negative assumptions about future social events are maintained (Brozovich and Heimberg 2008; Clark and Wells 1995; Hofmann 2007). As shown in clinical (e.g., Abbott and Rapee 2004; Kocovski and Rector 2008) and non-clinical student samples (e.g., Mellings and Alden 2000; Rachman et al. 2000), socially anxious individuals engage in more PEP than non-socially anxious individuals, and their PEP tends to intensify between events (e.g., Dannahy and Stopa 2007).

The link between PEP and SA is now well-established, however, the literature on PEP in the context of SA and drinking is in its infancy. One study by Battista et al. which included a sample high in SA, found that for females, PEP about a lab interaction was lower for those in the alcohol compared to no-alcohol condition. However, for males, PEP was higher for those in the alcohol compared to no-alcohol condition (Battista et al. 2014). This work highlights individual differences (in this case sex differences) in PEP for those high in SA in the context of alcohol. The next step is linking these individual differences in PEP after social drinking with future drinking risk. This may help to clarify the seemingly complex SA-drinking relation.

Returning to the idea of SA being a risk or protective factor, those who engage in less PEP after drinking may be at increased risk of drinking problems, while those who engage in more PEP may be at decreased risk (this would be consistent with the research on drinking-related regret; Cooke et al. 2007). Moreover, SA severity may play an important role in this risk versus protective pathway. To further complicate the picture, Potter and colleagues found that inducing PEP after a social stressor actually increased the urge to drink, suggesting that PEP is linked to increased risk of drinking problems for those high in SA (Potter et al. 2016). Although this study provides preliminary support for the role of PEP after non-drinking events in the association between SA and drinking risk, future research is needed to assess PEP following drinking events. Additionally, immediate urge to drink after PEP was assessed, however this cognitive process tends to intensify between events for those with SA (e.g., Dannahy and Stopa 2007), and thus may differentially affect future drinking if assessed hours later or the next day.

Taken together, PEP seems to be a critical component of the SA-alcohol risk model. On the one hand, for those with

elevated SA, morning-after social regret or PEP could be a deterrent to future drinking (i.e., PEP is a form of punishment). On the other hand, PEP may increase anxiety and promote further drinking in an attempt to decrease anxiety (i.e., alcohol use is negatively reinforced). To unpack this, we need to consider potential between-person differences over the unfolding, within person process from one event to the next.

The Current Study

Using ecological momentary assessments, PEP following social events and alcohol intoxication at subsequent events were assessed in a sample of young adults who spanned the range of SA. Over three consecutive weeks, participants were prompted daily on their smartphones to record information about the social events they attended the night before. Specifically, each morning they indicated the total number of drinks they consumed and their peak level of intoxication during the previous day's event, and current PEP related to the event. Due to concerns about the reliability of participants' responses for total number of drinks consumed,[1] the current study analyses focused on subjective intoxication. Therefore, the influence of PEP on peak subjective intoxication at the subsequent social event was of interest.

The primary objective of the current study was to test the moderating effect of individual differences in SA on the within-person association between PEP and alcohol intoxication. SA was examined as both a categorical and continuous variable. This is consistent with evidence demonstrating that alcohol risk may be specific to sub-clinical levels of SA (i.e., categorical approach; Crum and Pratt 2001), while also incorporating the extensive work demonstrating the variability in SA risk for alcohol misuse (i.e., continuous approach; e.g., Buckner et al. 2006). In an effort to integrate these approaches, we first split our sample into high and low SA groups. This was done based on a widely used SA measure and cut score (Mattick and Clarke 1998). Next, within each SA group, a continuous SA variable was tested as a moderator of the PEP-intoxication link.

We hypothesized that those in the high compared to low SA group would report elevated PEP overall, across the diary study. Given the conflicting theoretical and empirical evidence implicating PEP as a risk versus protective factor for alcohol misuse, we did not have a priori hypotheses about the direction of this association within the high and low SA groups. However, central to our study objective, we hypothesized that SA severity (within the SA groups) would moderate this effect. Considering SA in this nuanced way—as both a categorical and continuous variable when considering risk for alcohol misuse—may help to explain the mixed extant evidence for the SA-alcohol relation.

Materials and Method

Participants

Eligibility criteria included being 18 (legal drinking age in Quebec) to 30 years old, fluent in spoken English, consumed alcohol at least four times in the previous month, and had a touchscreen smartphone with a data plan. Based on recent survey data in Canada, over 80% of 18 to 34 year olds use a smartphone (eMarketer Inc. 2014), thus limiting concern about sampling bias. Additionally, we over-recruited on high SA. This was done by specifying SA as an eligibility criterion in approximately half of the advertisements and by tracking responses on a SA screening questionnaire (i.e., Social Interaction Anxiety Scale; Mattick and Clarke 1998; see "Materials" section). For the purpose of oversampling, we applied a widely used cut score on the SIAS to distinguish those meeting high and low SA criteria (e.g., Battista et al. 2014; Potter et al. 2016).

The initial sample included 120 English-speaking young adults (18–30 years; 79.2% female, 20% male, 0.8% transgender) living in Montreal, Quebec. Participants included in the final sample were those who attended a minimum of three social events over the 3-week study. A comparison of those included and excluded from data analyses revealed no significant differences on SA severity, drinking frequency (assessed at screening), and average PEP scores (all $ps > 0.05$). The 'first event' for each participant was one in which they indicated being at least mildly intoxicated at a social event (i.e., subjective intoxication scores > 0). This requirement permitted a test of the effects of PEP after an event in which a person was intoxicated on subsequent social event drinking. The final sample included 89 participants (discrete age categories were assessed: 25% aged 18–20, 44% aged 21–23, 14% aged 24–25, 17% aged 26–30; 82% female, 18% male). The majority were students (85%), were not living with family (72%), and less than half were working (43%).

[1] Some participants may have misread the question about drinks consumed and/or they may not have had the full question in view on their smartphone screens. Rather than providing the total number of drinks consumed prior to and during the previous night's social event, it seems that some indicated only the number of drinks consumed prior to the social event (i.e., pre-drinking). This interpretation of the data is based on a comparison of responses provided for the total number of drinks consumed and the peak level of intoxication, with some data points indicating 0 drinks consumed and > 0 level of intoxication.

Procedure

In response to the advertisements posted on university campuses and online (i.e., Craigslist, Kijiji), individuals contacted the lab. A hyperlink to the online screening was sent by email. Those eligible for the study were directed to a second online questionnaire, which included baseline measures. Informed consent was obtained from all participants prior to both the screening and baseline/study procedures. Starting on the next Tuesday at 11:00 AM—following the baseline and continuing for 21 consecutive days—participants received a text message on their smartphones. This included a hyperlink to a brief questionnaire, which first asked participants to indicate whether or not they attended a social event the night before. Social events were defined as any social situation or gathering in which the participant was in the presence of one or more individuals. If yes, participants indicated perceived peak alcohol intoxication at the event and current post-event processing related to the event. To minimize recall bias, questionnaires completed after 6:00 PM were not included in the analyses; this accounted for 3% (i.e., 53 data points) of the completed questionnaires. This is consistent with previous studies using smartphones for data collection (e.g., Goldstein et al. 2014; Kuntsche and Labhart 2013; Paolillo et al. 2018). The average response time to morning surveys sent at 11:00 AM was 1 h and 8 min (after excluding participants who completed morning surveys after 6:00 PM on the day they were sent). All questionnaires were programmed in *Fluidsurveys*. Participant were compensated up to 5 course credits or $90 (Canadian currency). Compensation was prorated based on the number of completed daily questionnaires.

Materials

Social Interaction Anxiety Scale (SIAS)

The 20-item SIAS (Mattick and Clarke 1998) was administered as part of the screening to permit oversampling on high social interaction anxiety, which is described as distress when meeting and talking with others (Mattick and Clarke 1998). We selected the SIAS as the screening measure (and the SPS as the grouping measure; see below) because of its specificity in detecting SA relative to other forms of anxiety (Brown et al. 1997). Participants indicated on a 5-point scale (0 = *not at all* to 4 = *extremely*) how characteristic each item (e.g., *I have difficulty making eye-contact with others*) was of them. A sum score was derived. The scale demonstrated excellent internal consistency in the current study ($\alpha = 0.95$) and has demonstrated internal consistency ($\alpha = 0.93$), discriminant validity, and retest reliability ($r > 0.90$) in previous studies (Brown et al. 1997; Heimberg et al. 1992; Mattick and Clarke 1998). For recruitment purposes only, and consistent with previous literature, a cut score of 34 on the SIAS was used to ensure more than half of the sample (58%) was high in SA related to social interactions (Heimberg et al. 1992).

Social Phobia Scale (SPS)

The 20-item SPS (Mattick and Clarke 1998) was administered at baseline and was used for SA grouping for the purpose of hypothesis testing. The SPS was developed as a complimentary measure to the SIAS (Carleton et al. 2009) and assesses general performance-related social anxiety. Relative to the SIAS, which was used as the SA screening measure, the SPS better captures potential anxiety-provoking triggers encountered during social events. As such, it was the measure of choice for determining SA severity and grouping. Participants indicated on a 5-point scale (0 = *not at all* to 4 = *extremely*) how characteristic each item (e.g., *I am worried people will think my behaviour is odd)* was of them. A sum score was derived. The scale demonstrated good internal consistency in the current study ($\alpha = 0.94$), and has shown good internal consistency ($\alpha = 0.89$–0.94), discriminant validity, and retest reliability ($r > 0.90$) in previous studies (Brown et al. 1997; Heimberg et al. 1992). To categorize individuals into high and low SA groups, a recommended and widely utilized cut score of 24 was used (Heimberg et al. 1992). The high SA group included those scoring > 24 on the SPS, and the low SA group included those scoring ≤ 24. SPS scores were also retained on a continuous variable and used for moderation analyses within the high and low SA groups.

Subjective Intoxication Rating Form (SIRF)

The single-item SIRF (Himle et al. 1999; Kushner et al. 1996) was administered in the daily 11:00 AM survey if a social event was attended the night before. Participants indicated on a visual-analogue scale the highest level of intoxication they felt (0 = *Completely sober* to 100 = *Completely intoxicated*) the night before. This is an often-used measure of subjective intoxication (e.g., Battista et al. 2014, 2012).

Post-event Processing Questionnaire-Revised (PEPQ-R)

The 14-item PEPQ-R (McEvoy and Kingsep 2006; original PEPQ; Rachman et al. 2000) was administered in the daily 11:00 AM survey if a social event was attended the night before. Instructions were adapted for the current study such that PEP about the previous night's social event was assessed. Responses were made on a visual-analogue scale. The first item assessed how much anxiety participants were experiencing at the moment (1 = *none at all* to 100 = a *lot*), while the remaining items assessed how much

PEP participants were currently engaging in (0 = *not at all* to 100 = *very much;* e.g., *Are you trying to resist thinking about the event?*). Based on an exploratory factor analysis of the PEPQ-R, conducted by Rachman et al. (2000), and our confirmatory factor analysis (Bentler Comparative Fit Index = 0.89), three items were excluded from the total (sum) scale score. These items had low loadings and appeared to be less closely linked to the construct of PEP compared to the other 11 items. Similar to previous work (α = 0.85; Rachman et al. 2000), the 11-item PEPQ-R demonstrated good internal consistency (α = 0.90–0.94 across days included in the analyses) in the current study.

Results

Data Screening

There were no outliers (±|3.29|; Tabachnick and Fidell 2007) on the variables of interest. All variables had acceptable skew (< 3.00) and kurtosis (< 10.00) (Kline 2009). The 89 participants provided 1674 days of data, thus the compliance rate was 89.6% with the daily morning surveys (mean number of days completed per participant was 18.81 out of 21, *SD* = 2.76; mode = 21). This is consistent with previous research using a daily diary protocol to investigate SA and alcohol use (O'Grady et al. 2011). On nine different days within the 21-day cycle, across nine different participants, morning surveys were started but not completed. Maximum likelihood was used as the estimator and accounts for incomplete and missing data.

Statistical Analyses

Multilevel models were estimated using Mplus (Muthén and Muthén 2007); this allowed us to account for the two-level data structure (i.e., within- and between-person). The first social event included in the analyses were those in which participants indicated being intoxicated (SIRF scores > 0). After identifying this first social drinking event within the 21 days, participants who attended at least two subsequent social events were included in the analyses (*N* = 89). Therefore, the final analyses included data for a minimum of three events per participant, allowing for a minimum of two data cycles to be examined. Each data cycle included a score for PEP the morning after a social event, and a score of peak subjective intoxication at the subsequent social event. Two data cycles (i.e., three social events) were available for 76% of the sample and three data cycles (i.e., four social events) were available for 67% of the sample. We chose to stop at three data cycles as only just over half of the sample (56%) provided data for four cycles (i.e., five social events). The mean number of data cycles (for those included in the analyses) was 2.83 for those high in SA and 2.82 for those low in SA.

To assess within-person and cross-level moderation models, the high and low SA groups (defined by SPS scores) were examined separately. Within-person regression models were used to examine the effect of PEP (PEPQ-R) after each social event on peak subjective intoxication (SIRF) at the next social event. Cross-level moderation models were used to evaluate whether the strength of the within-person effect (i.e., PEP on next-event intoxication) was influenced by baseline SA severity, which was the between-person variable of interest. Specifically, the SPS continuous variable was tested as a moderator of the within PEP-subjective intoxication effect separately in the high and low SA groups.

Preliminary Analyses

Multinomial and binary logistic regressions were completed to determine the association between demographic variables and SA grouping (i.e., high versus low). Participants in the high and low SA groups (based on SPS cut score) were similarly distributed across age ($\chi^2_{(1)} = 0.27$, $p = 0.61$; high/low SA: 75%/80% 18–24 years), sex ($\chi^2_{(1)} = 0.01$, $p = 0.92$; high/low SA: 83%/82% female), student status ($\chi^2_{(1)} = 1.69$, $p = 0.19$; high/low SA: 80%/90% students), work status ($\chi^2_{(4)} = 2.91$, $p = 0.57$; e.g., high/low SA: 60%/55% not working), and ethnic group ($\chi^2_{(6)} = 7.16$, $p = 0.21$; e.g., high/low SA: 65%/55% European-Canadian).

Independent samples *t*-tests were used to compare the high and low SA groups on a number of variables. No statistically significant differences emerged on the number of drinks consumed during a typical drinking week in the previous month ($t = 0.43$, $p = 0.67$; $M = 11.60$, $SD = 7.11$ for high SA; $M = 10.94$, $SD = 7.30$ for low SA), and during the heaviest drinking week in the previous month ($t = 0.04$, $p = 0.97$; $M = 18.85$, $SD = 11.08$ for high SA; $M = 18.73$, $SD = 15.12$ for low SA). No statistically significant group differences emerged on the average subjective intoxication rating scores (SIRF; $t = -0.56$, $p = 0.58$). Statistically significant differences were found on SA symptom severity scores (SIAS, $t = -12.32$, $p < 0.001$; SPS, $t = -22.12$, $p < 0.001$) and average post-event processing scores (PEPQ-R, $t = -2.43$, $p = 0.01$) with the high SA group scoring higher than the low SA group (Table 1). At the bivariate level, in the high SA group there was a statistically significant positive correlation between PEP and next-event SIRF scores (Table 1).

All participants were intoxicated at the first event included in the cycle (as per the cycle selection criteria), while 80.9% of the sample (81% and 80.8% in the low and high SA group, respectively) indicated being intoxicated (SIRF > 0) at the subsequent two or three events included in the cycle. Thus, the majority of PEP scores were from social events that involved alcohol use.

Table 1 Bivariate correlations and descriptive statistics: total sample (N = 89), and high (n = 40) and low (n = 49) social anxiety groups

	SIAS	SPS	PEPQ-R	Mean	SD
Total sample					
1. SIAS				35.36	16.81
2. SPS	0.73**			24.18	14.93
3. PEPQ-R	0.11^{+}	0.12*		24.39	19.03
4. SIRF	0.03	0.03	0.13*	49.73	30.83
High SA (SPS score > 24)					
1. SIAS				46.38[1]	11.18
2. SPS	0.51**			37.70[2]	10.79
3. PEPQ-R	−0.13	−0.09		27.52[3]	20.22
4. SIRF	0.10	−0.03	0.28**	50.94[4]	30.33
Low SA (SPS score ≤ 24)					
1. SIAS				26.41[1]	15.26
2. SPS	0.67**			13.14[2]	6.21
3. PEPQ− R	0.13	0.14^{+}		21.79[3]	17.62
4. SIRF	−0.05	0.03	−0.01	48.77[4]	31.30

SIAS social interaction anxiety scale (screening SA), *SPS* social phobia scale (baseline SA grouping variable), *PEPQ-R* post-event processing questionnaire-revised (the average of 3–4 PEP scores, assessed the morning after a social event), *SIRF* subjective intoxication rating form score (the average of 3–4 peak subjective intoxication scores, assessed the morning after a social event)

Subscript numbers indicate high versus low SA group differences (t-tests), [1,2]$p < 0.01$; [3]$p = 0.01$; [4]$p = 0.58$

$^{+}p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$

Table 2 Main effect and cross-level moderation model results predicting subjective intoxication (SIRF scores) among the high (n = 40) and low (n = 49) social anxiety groups

	High SA (SPS score > 24)		Low SA (SPS score ≤ 24)	
	B	(SE)	B	(SE)
Main effect model				
PEPQ-R (within-person)	0.39*	(0.15)	−0.04	(0.15)
SPS (between-person)	−0.05	(0.42)	0.23	(0.43)
Intercept	42.69**	(16.58)	46.39**	(6.44)
Cross-level moderation model				
SIRF ON SPS	0.76	(0.53)	0.56	(0.82)
Slope ON SPS	−0.04^{+}	(0.02)	−0.02	(0.02)
Intercept				
SIRF	12.26	(20.95)	42.32**	(10.44)
Slope	1.75*	(0.76)	0.15	(0.34)

B unstandardized regression coefficients, *SE* standard error, *SPS* social phobia scale (baseline SA), *PEPQ-R* post-event processing questionnaire-revised (assessed the morning after a social event), *SIRF* subjective intoxication rating form score (assessed the morning after a social event)

$^{+}p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$

Main Effect Models: PEPQ-R and SPS Predicting SIRF

The main effect model results are summarized in Table 2. In the high SA group (SPS > 24), each unit increase in post-event processing (PEPQ-R) was associated with a 0.39-unit increase in peak subjective intoxication (SIRF) ($p = 0.01$). In the low SA group (SPS ≤ 24), the association between PEP and peak subjective intoxication was not statistically significant ($p = 0.78$). In both the high and low SA groups, the effect of baseline SA (SPS) on peak subjective intoxication (SIRF) was not statistically significant ($p = 0.90$, $p = 0.59$ respectively).

Cross-level moderation model: SPS predicting within-person slope

The cross-level moderation model results are summarized in Table 2. Within the high SA group, examination of the slope at intercept revealed that elevated post-event processing (PEPQ-R) was associated with increased peak subjective intoxication (SIRF) at the next event ($p = 0.02$). However, this slope decreased in magnitude by a factor of 0.04 with each unit increase in baseline SA severity (SPS) ($p = 0.07$).[2] This is evident by the parameter estimate for the PEPQ-R-to-SIRF slope regressed on between-subject SPS. In contrast, within the low SA group, neither the slope at intercept ($p = 0.65$) nor the cross-level moderation ($p = 0.52$) was supported.

To interpret the cross-level interaction for the high SA group (SPS > 24), slopes were plotted (Fig. 1). Within the high SA group, the effect of PEPQ-R on SIRF was plotted at 'high' (+1 *SD* of mean in *high SA group*) and 'low' (−1 *SD* of mean in *high SA group*) SPS. Keeping in mind that 'high' reflects above the mean of the high group and 'low' reflects below the mean of the high group, the latter may be thought of as 'moderate/high' on SA. The slopes suggest that PEPQ-R was associated with increased SIRF, but only for those 'low' on SPS (−1 *SD* or moderate/high SA). Thus, at moderate/high SA, with increased PEP the morning after a social event there appeared to be increased perceived peak intoxication at the next social event. This effect was not observed at 'high' SPS (+1 *SD* or high SA).

[2] Moderator effects are difficult to detect, particularly in small samples; as such, the alpha was set at 0.10 to reduce Type II error (Aguinis and Stone-Romero 1997; McClelland and Judd 1993).

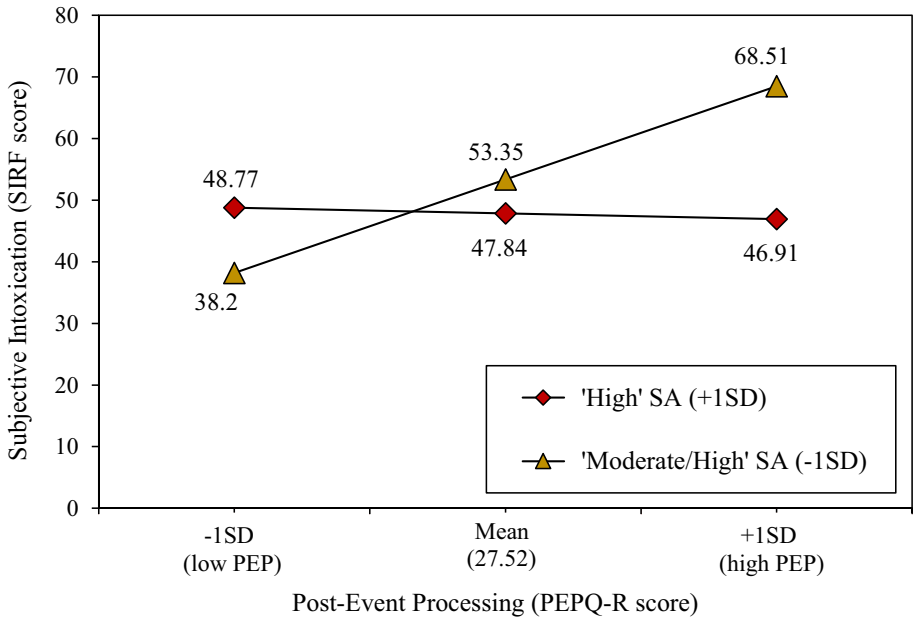

Fig. 1 Cross-level moderation with social anxiety severity (plotted at + 1 *SD* and − 1 *SD* in the high SA group; SPS > 24, $n = 40$) moderating the relation between post-event processing and next-event peak subjective intoxication. *SA* social anxiety, *SPS* social phobia scale (baseline SA), *PEPQ-R* post-event processing questionnaire-revised (assessed the morning after a social event), *SIRF* subjective intoxication rating form (peak subjective intoxication score assessed the morning after a social event)

Discussion

By administering a daily diary methodology via participants' personal smartphones, we examined how PEP (the cognitive variable of interest) after social drinking events influenced alcohol intoxication at subsequent events among individuals who span the range of SA severity. Consistent with the literature, which has found that high SA is not necessarily predictive of the amount of alcohol consumed (Morris et al. 2005), the results showed that perceived intoxication did not differ across levels of SA. Furthermore, consistent with theory and research demonstrating that PEP is highly prevalent among those with elevated SA (e.g., Clark and Wells 1995; Kocovski and Rector 2008; Rachman et al. 2000), those high in SA reported more PEP (on average) after social events compared to those low in SA. However, in the high SA group, PEP after an event was positively associated with intoxication at the next event, whereas in the low SA group PEP and intoxication were unrelated. Taken together, these initial results suggest that PEP alone, following a social event in which an individual was intoxicated, is not sufficient for understanding the link between SA and drinking risk.

By splitting into high and low SA groups, and considering the within-group interactive effects of PEP and SA, the current study tested and confirmed that PEP serves as a risk factor for subsequent intoxication, but only for a subset of individuals high in SA. Specifically, PEP about a social event in which the individual was intoxicated promoted future intoxication for those at the low end of the high SA group; what we might refer to as moderate/high in SA. Whereas, for the low SA group, PEP was unrelated to subsequent intoxication, and SA severity within this group did not moderate this effect. By testing the moderation model within high and low SA groups, the current study helps to clarify the mixed results in the SA and alcohol use literature. The results are consistent with findings that subclinical SA (i.e., having elevated but not clinical levels of SA) increases risk for alcohol use problems (Crum and Pratt 2001). In addition, the current findings are in line with previous research which has found that those moderately high in SA are at greater risk for having alcohol problems relative to those high and low in SA (Strahan et al. 2011).

A compelling explanation for the increased risk among those with moderate/high SA is that their repetitive negative thinking about a previous social drinking event increases feelings of anxiety and thus, when they attend the next social drinking event, they drink in an attempt to decrease anxiety associated with both PEP and the current social event. This negative reinforcement hypothesis would benefit from a future investigation that models the prospective effects of PEP on next-event anxious affect and subsequent drinking. Notably, our finding that elevated PEP predicted increased intoxication is not consistent with the regret literature, which found that regret following binge-drinking was associated with reduced intention to binge-drink in the future (Cooke et al. 2007). Possibly this difference between our findings and those of Cooke and colleagues reflects differences in intention and actual behaviour. Taken together, our results suggest that PEP may be central to SA risk for alcohol misuse, but moreover, and consistent with Crum and Pratt's (2001) work, our results point to the importance of not simply considering SA on a continuum in models of alcohol risk.

The results from the current study, when considered within the context of the broader literature, may have clinical implications. It appears that not all individuals with SA are at risk of developing alcohol use problems; individuals moderately high in SA who PEP about social drinking events may be at risk for becoming intoxicated during the next social events. This could offer a targetable mechanism in the trajectory to the development of alcohol use disorder. First, these results may be incorporated in alcohol abuse prevention initiatives for students in university. Through an understanding of how PEP after social drinking can influence future drinking for those moderately high in SA, students can make more informed decisions about their social drinking and this may ultimately prevent the development of longer-term problems with alcohol. Second, clinicians may have the opportunity to intervene in psychotherapy by identifying those who are moderately high in SA and who PEP. For example, clinicians may focus on strategies to cope with PEP in addition to the actual social events. Targeting coping strategies is consistent with extant recommendations for the treatment of concurrent SA and AUD (Mueser et al. 2003). However, our work suggests the extension of this to social anxiety stemming from morning after alcohol-related rumination.

A major strength of the current study is the use of ecological momentary assessments via participants' personal smartphones. By using this method, participants responded to text messages from the study coordinators, and could access the provided hyperlinks immediately or shortly after they were received. This allowed for a high response rate to morning surveys. In addition, limiting the amount of time between social events and reports about these social events, including peak intoxication levels during the previous night and morning-after PEP, likely decreased recall bias. Additionally, this 21-day ecological momentary assessment method allowed us to test the prospective link between PEP and alcohol intoxication. With 21-days, we were somewhat limited in the number of drinking events that we could include in the analyses. Future research may consider a longer period, permitting inclusion of a larger number of events. Furthermore, the current study collected data from participants who attended social events, and did not directly investigate the effect of PEP on avoidance of subsequent social events. Those with elevated SA may avoid social situations and therefore have fewer opportunities to drink alcohol (e.g., Battista et al. 2010; Schry and White 2013). Future research may benefit from considering the role of PEP in avoidance of social drinking and possible preference for solitary drinking. Moreover, the current study sample was predominantly female, and thus underpowered to test the moderation effect of gender in the model. However, given that findings from the extant literature demonstrate gender differences in the link between SA and alcohol use (e.g., Randall et al. 2000), the role of gender should be considered in future tests of the current model of PEP and drinking, moderated by SA severity.

Despite its notable strengths and relevant clinical implications, the study has limitations. First, a non-clinical sample was used, and SA severity was determined by a questionnaire rather than a clinical diagnostic interview. This study should be replicated with a clinical sample of individuals who are assessed and diagnosed with SAD or subclinical SAD by clinical interview.

Second, participants' PEP about a social event was only assessed the morning after the event. Previous research has shown that PEP intensifies over several days following social events (Dannahy and Stopa 2007). While this previous work did not consider PEP related to drinking events, examination of PEP over a longer period following a social drinking event may help to clarify this risk pathway. We speculate that subsequent drinking by those moderate/high in SA may be prompted by the drive to reduce PEP from the last event. Examination of PEP across multiple days, and prior to the next event would permit an empirical test of this hypothesis.

Third, although the association between PEP and subsequent event intoxication was of interest, not all of the obtained PEP scores reflect PEP after drinking. Only the first event for each participant controlled for intoxication, requiring at least slight intoxication. While approximately 80% of all events in the dataset involved some level of intoxication, it is important to note that approximately 20% did not. As such, a potential limitation is that some PEP scores were provided for events in which the participants were not intoxicated. On the other hand, including these events permitted a rigorous test of our hypothesis, as we were able to assess effects of PEP on the full range of next-event drinking behaviours, including abstinence.

Finally, the study focused on peak subjective intoxication as the primary drinking outcome and not drinks consumed. This was due to concerns with the reliability of the total number of drinks consumed score. Although this is a limitation, we would argue that subjective intoxication is more relevant than drink counts to the current study. We were interested in examining the process through which individuals with SA may develop alcohol use problems, and specifically the relation between post-drinking PEP and efforts to *feel* intoxicated and experience tension reduction. This process emphasizes the subjective experience with alcohol. Additionally, intoxication is thought to be a useful measure of drinking as it relies less on memory for the specific details that are required for report of standard number of drinks consumed. Nonetheless, correlations supported a positive association ($r = 0.551$, $p < 0.001$) between-subjective intoxication scores and number of drinks consumed.

Our study provides evidence suggesting that PEP after a social drinking event is a risk factor for subsequent

drinking for those who are moderate/high in SA. The current study offers some resolution to the mixed support for a SA-problematic drinking risk pathway. Although previous studies have made similar attempts to clarify the link between SA and alcohol use, few have examined process variables, their influence on drinking over time, and how these effects differ across the SA continuum. By examining effects of post-intoxication PEP and next-event intoxication across individuals with varying degrees of SA, we found that neither SA severity nor PEP, alone, predict drinking; rather, it is how these variables interact that clarifies SA risk for problematic drinking.

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Compliance with Ethical Standards

Conflict of Interest Avital Ogniewicz, Emmanuel Kuntsche, and Roisin M. O'Connor declare that they have no conflict of interest.

Informed Consent All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Animal Rights No animal studies were carried out by the authors for this article.

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