



## Social discomfort moderates the relationship between drinking in response to negative affect and solitary drinking in underage drinkers



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### HIGHLIGHTS

- Solitary drinkers report more social discomfort, alcohol use, and alcohol problems.
- Social discomfort moderates the link from negative affect drinking to drinking alone.
- Contrary to prediction, lower social discomfort strengthens this link.
- Findings are discussed in regard to negative interpersonal interactions.

### ARTICLE INFO

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### ABSTRACT

**Objective:** Research shows that solitary drinking is associated with negative reinforcement motives (i.e., relieving negative affect). An untested hypothesis proposes that this association may be especially strong for individuals who experience social discomfort. This study aimed to 1) replicate findings linking solitary drinking to social discomfort (i.e., loneliness, social anxiety, and lack of perceived social support), alcohol problems, and drinking in response to negative affect (i.e., drinking to cope motives and inability to resist alcohol during negative affect), and 2) investigate whether greater social discomfort moderates the relationship between drinking in response to negative affect and solitary drinking in underage drinkers.

**Method:** Current alcohol drinkers ages 18 to 20 ( $N = 664$ ) recruited from a TurkPrime panel reported the percentage of time they drank solitarily and completed measures assessing social discomfort, drinking in response to negative affect, and alcohol involvement. Structural equation modeling was used to test the moderation model.

**Results:** Results replicated prior literature supporting the first aim. For the second aim, analyses indicated a positive association between solitary drinking and drinking in response to negative affect across all individuals, but contrary to prediction, this relationship was stronger for individuals with lower, rather than higher, social discomfort.

**Conclusion:** Underage drinkers with lower, rather than higher, social discomfort appear to be at greater risk for drinking alone. These findings may inform our understanding of individuals at greatest risk for drinking alone and promote new avenues for intervention.

### 1. Introduction

Solitary drinking in youth is associated with numerous negative psychosocial outcomes including heavier and more frequent alcohol consumption (Creswell, Chung, Clark, & Martin, 2014; Gonzalez, Collins, & Bradizza, 2009; Tucker, Ellickson, Collins, & Klein, 2006) and is predictive of young adult alcohol problems above and beyond early alcohol use and problems (Creswell et al., 2014; Tucker et al., 2006). Additionally, young solitary drinkers report more legal and behavioral

problems, and experience poorer physical health and academic outcomes than social-only drinkers (Christiansen, Vik, & Jarchow, 2002; Tucker et al., 2006). Thus, youth who engage in solitary drinking seem at risk for a wide array of negative consequences, suggesting that solitary drinking measures may be a useful addition to routine screening for alcohol problems.

Because solitary drinking is associated with various problems, it is important to identify why individuals drink alone and for whom this association may be particularly relevant. Research has found that youth

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**Table 1**  
Correlations among study variables.

Variables	Solitary	AUDIT	YAACQ	DMQ-R	DRSE	ISEL-A	ISEL-B	SIAS	UCLA	Freq	Quant	Max F	Max Q	1st Drink	Intox
Solitary	–														
AUDIT	0.30***	–													
YAACQ	0.22***	0.68***	–												
DMQ-R	0.27***	0.46***	0.53***	–											
DRSE	–0.35***	–0.53***	–0.51***	–0.51***	–										
ISEL-A <sup>a</sup>	–0.11**	–0.15***	–0.19***	–0.13**	0.19***	–									
ISEL-B <sup>a</sup>	–0.21***	–0.07	–0.06	–0.15***	0.19***	0.41***	–								
SIAS <sup>a</sup>	0.15***	0.10*	0.12**	0.25***	–0.14*	–0.11*	–0.47***	–							
UCLA <sup>a</sup>	0.14**	0.12**	0.15***	0.32***	–0.24***	–0.33***	–0.58***	0.60***	–						
Freq <sup>b</sup>	–0.19***	–0.55***	–0.49***	–0.31***	0.33***	0.04	–0.07	0.02	–0.00	–					
Quant <sup>b</sup>	–0.12**	–0.56***	–0.45***	–0.33***	0.36***	0.13**	0.01	–0.01	–0.02	–0.42***	–				
Max F <sup>b</sup>	–0.15***	–0.53***	–0.40***	–0.27***	0.40***	0.18***	0.08	–0.00	–0.06	0.51***	0.54***	–			
Max Q <sup>b</sup>	–0.07	–0.49***	–0.46***	–0.30***	0.25***	0.01	–0.08	0.03	0.05	0.47***	0.66***	0.34***	–		
1st Drink	–0.11**	–0.14***	–0.21***	–0.17***	0.17***	0.09*	0.05	–0.05	–0.14**	0.11**	0.14***	0.12**	0.21***	–	
Intox	–0.13**	–0.18***	–0.22***	–0.14**	0.15***	0.13**	0.06	–0.06	–0.11*	0.10*	0.15***	0.20***	0.19***	0.71***	–
Mean	25.33	8.63	6.24	2.30	29.45	11.05	11.54	30.79	48.46	5.65	7.40	7.20	5.95	14.86	15.96
SD	28.34	6.44	5.81	1.06	8.41	1.89	2.78	15.90	11.97	1.96	2.00	2.11	1.91	3.09	2.50

Note.  $N = 660$ .

Solitary = Percentage of drinking time spent alone; AUDIT = Alcohol Use Disorder Identification Task; YAACQ = Brief Young Adult Alcohol Consequences Questionnaire; DMQ-R = Drinking Motives Questionnaire-Revised Drinking to Cope subscale; DRSE = Drinking Refusal Self-Efficacy Emotional relief subscale; ISEL-12 = Interpersonal Support Evaluation List—A = Appraisal, B = Belonging; SIAS = Social Interaction Anxiety Scale; UCLA = UCLA Loneliness scale; Freq = Past year alcohol frequency; Quant = Past year alcohol quantity; Max F = Past year maximum drinking frequency; Max Q = Past year maximum drinking quantity; 1st drink = Age at first alcoholic drink; Intox = Age at first intoxication experience.

<sup>a</sup> As noted in the Discussion, the sample as a whole tended to report higher levels of loneliness and social anxiety, and lower levels of social support compared to other samples.

<sup>b</sup> Quantity and frequency variables were coded such that greater numbers correspond to lower frequency and fewer drinks per occasion (NIAAA, 2003). See Supplementary Material for response options and frequencies.

\*  $p < 0.05$ .

\*\*  $p < 0.01$ .

\*\*\*  $p < 0.001$ .

may drink alone to relieve negative emotions (Creswell et al., 2014; Creswell et al., 2015; Tomlinson & Brown, 2012). For instance, solitary drinking is associated with drinking to cope motives (Cooper, 1994; Cooper, Russell, Skinner & Windle, 1992; Gonzalez et al., 2009; Gonzalez & Skewes, 2013; Williams, Vik, & Wong, 2015) and negative reinforcement expectancies for alcohol use (Tucker et al., 2006). Further, negative emotionality predicts solitary drinking in both adolescents and young adults (Christiansen et al., 2002; Creswell et al., 2015; Gonzalez et al., 2009; Tomlinson & Brown, 2012), and the inability to resist drinking while experiencing negative affect has been found to mediate the relationship between negative emotionality and solitary drinking (Creswell et al., 2015).

While negative reinforcement has been examined as a mechanism for solitary drinking, there may be individuals particularly vulnerable to this behavior. Indeed, individuals who report social discomfort like loneliness, social anxiety, and a lack of perceived social support might be especially likely to drink in response to negative affect. Partially supporting this, several studies have linked solitary drinking to social discomfort. Solitary drinking is associated with lower perceived social competence and greater loneliness in college students and young adults (Arpin, Mohr, & Brannan, 2015; Gonzalez & Skewes, 2013). In addition, social anxiety, which is robustly associated with drinking to cope motives (Blumenthal, Leen-Feldner, Frala, Badour, & Ham, 2010; Stewart, Morris, Mellings, & Komar, 2006; Thomas, Randall, & Carrigan, 2003; Windle & Windle, 2012) and problematic alcohol use (see Buckner, Heimberg, Ecker, & Vinci, 2013 for a review), is predictive of solitary drinking (Buckner & Terlecki, 2016) and solitary “pre-drinking” (i.e., drinking prior to going out; Keough, Battista, O’Connor, Sherry, & Stewart, 2016).

However, findings linking social factors to solitary drinking are somewhat inconsistent. Adolescent solitary drinkers report spending more time attending parties and dating than social-only drinkers (Tucker et al., 2006), and there were no social network size differences in solitary and social-only heavy drinking college students (Gonzalez & Skewes, 2013). Taken together, these results suggest that despite being socially active, solitary drinkers may experience more social discomfort

than social-only drinkers (Gonzalez & Skewes, 2013). Prior studies have not tested whether perceived social discomfort strengthens the link between drinking in response to negative affect and solitary drinking. This test might help identify individuals more likely to engage in solitary drinking, and thus aid prevention and intervention programs aimed at targeting those most at risk.

The present study had two aims. The first was to replicate prior research indicating solitary drinking associations with greater social discomfort (i.e., higher levels of loneliness and social anxiety and lower perceived social support), greater endorsement of drinking in response to negative affect (i.e., drinking to cope motives and inability to resist alcohol during negative affect), greater consumption of alcohol (i.e., quantity and frequency), and more negative alcohol-related consequences in a sample of 664 underage drinkers (ages 18–20). The second aim was to investigate whether the relationship between drinking in response to negative affect and solitary drinking was moderated by social discomfort using structural equation modeling (SEM). We hypothesized that greater social discomfort would magnify this relationship.

## 2. Methods

### 2.1. Participants

Participants were recruited through an Amazon TurkPrime panel, which uses multiple websites to recruit interested individuals for research surveys (e.g., Amazon Mechanical Turk; see below for more details). Among 727 eligible individuals who were 18–20 years old and current alcohol drinkers residing in the United States, 703 completed at least one of the questionnaires within the survey (participants were able to skip items). Of these, 660 answered the solitary drinking question and were included in bivariate correlations in Table 1. SEM analyses included 664 participants ( $M_{\text{age}} = 19.2$ ,  $SD = 0.78$ ) due to the default in Mplus to estimate the model under missing data theory using all available data.

Most participants were female (87.2%), single (78.1%), and in

college (63.9%). The majority of the sample self-identified as Caucasian (67.6%), while 13.0% identified as African American, 11.4% as multi-racial, 5.0% as Asian, 2.1% as American Indian or an Alaska Native, and 0.9% as Native Hawaiian or other Pacific Islander; 84.5% identified as non-Hispanic/Latino. A minority of participants were in high school (8.6%) or not a student (27.5%) and had a full-time job (14.0%), while 49.1% had a part-time job, and 37.0% were unemployed. Most unemployed participants were students (58.1% college; 10.6% high school).

Amazon TurkPrime uses multiple websites (e.g., Amazon Mechanical Turk) for recruitment. Alcohol data obtained through such sites has been shown to be reliable and valid (Kim & Hodgins, 2017; Meisel, Colder, & Read, 2016). For our study, the panel service sent a pre-specified screening questionnaire to recruitment sources with eligibility questions (i.e., age, US residence, and current drinking status) embedded in a more general questionnaire, ensuring that participants were unaware of eligibility criteria and increasing the chances of honest responding. Ineligible participants were unable to reenter the survey. Eligible participants were sent a link to the online Qualtrics survey, which took approximately 30–45 min to complete. The study was approved by the Carnegie Mellon University Institutional Review Board, with all participants providing informed consent. Payment was designated as \$5 through the TurkPrime panel website.

## 2.2. Measures

### 2.2.1. Drinking in response to negative affect

'Drinking in Response to Negative Affect', the main predictor variable in SEM analyses, included two conceptually similar measures. The first was the Drinking to Cope subscale of the Drinking Motives Questionnaire-Revised (DMQ-R; Cooper, 1994), which measures an individual's motivation for drinking to alleviate negative affect. The DMQ-R has demonstrated good criterion validity (Kuntsche, Knibbe, Gmel, & Engels, 2006). Reliability was good ( $\alpha = 0.86$ ). The second measure was the Emotional Relief subscale of the Drinking Refusal Self-Efficacy Questionnaire—Revised Adolescent Version (DRSEQ-RA; Young, Hasking, Oei, & Loveday, 2007), which assesses an individual's belief in their ability to resist alcohol during negative affect. It has demonstrated good reliability and criterion validity (Young et al., 2007). Reliability was excellent ( $\alpha = 0.95$ ).

### 2.2.2. Social discomfort

'Social discomfort', the moderator variable in SEM analyses, was represented by three constructs: perceived social support, loneliness, and social anxiety. Previous research shows that these interpersonal problems are often correlated with one another (Anderson & Harvey, 1988; Cohen, Sherrod, & Clark, 1986; Lakey, 1989; Riggio, Watring, & Throckmorton, 1993; Turner, 1981) and are thought to stem from perceived social deficits such as poor social skills (Riggio et al., 1993; Segrin & Flora, 2000).

Perceived social support was represented by 2 subscales of the Interpersonal Support Evaluation List—Shortened Version (ISEL-12): Appraisal Support (availability of people to talk to about one's problems) and Belonging Support (availability of people with whom one can do things). The ISEL-12 (Cohen, Mermelstein, Kamarck, & Hoberman, 1985) has demonstrated good convergent and criterion validity (Cohen et al., 1985; Creswell et al., 2015). Reliability was acceptable for both subscales ( $\alpha = 0.71$  and  $0.73$ , respectively). Loneliness was measured by the UCLA Loneliness Scale, V3 (Russell, 1996). It has demonstrated high internal consistency (e.g., Russell, Kao, & Cutrona, 1987) and good convergent validity (Russell, 1996). Reliability was excellent ( $\alpha = 0.92$ ). Finally, social anxiety was measured with the Social Interaction and Anxiety Scale (SIAS; Mattick & Clarke, 1998) which assesses fear of social interactions. It has shown good concurrent validity with other widely used measures of social anxiety (Caballo, Salazar, Iruartia, Arias, & Nobre, 2013). Reliability was

excellent ( $\alpha = 0.93$ ).

### 2.2.3. Alcohol consumption and context

Past year alcohol use quantity (standard drinks/occasion) and frequency (days/year) were measured using the National Institute of Alcohol Abuse and Alcoholism's (NIAAA) alcohol consumption question set (NIAAA, 2003).<sup>1</sup> These items were included as covariates in SEM analyses to demonstrate that drinking in response to negative affect and social discomfort are related to solitary drinking above and beyond general alcohol consumption. We also assessed age at first drink and intoxication experience, past year maximum drink quantity during one occasion, and frequency of drinking this amount (NIAAA, 2003). To assess solitary drinking, participants were asked to indicate the percentage of time that their drinking occurred while alone (i.e., "without anyone else around") versus with others (on a 0–100% scale) since they began drinking (see Creswell et al., 2014; Creswell et al., 2015).

### 2.2.4. Alcohol-related problems

Two questionnaires assessed alcohol problems in the past year. The first was the Alcohol Use Disorder Identification Test (AUDIT; Saunders, Aasland, Babor, De la Fuente, & Grant, 1993), which assesses problematic alcohol use and related behavior. The second was the Brief Young Adult Alcohol Consequences Questionnaire (B-YAACQ; Kahler, Strong, & Read, 2005), which assesses negative consequences associated with alcohol use. Reliability was good for both ( $\alpha = 0.84$  and  $0.92$ , respectively).<sup>2</sup>

### 2.2.5. Data quality

To control for careless responding, four questions to assess attention (i.e., "attention checks") were randomly embedded within the survey. An example item was, "Select [option 3] if you are paying attention". Number of correct attention checks was included as a covariate in SEM analyses.<sup>3</sup>

## 3. Data analysis

Bivariate correlations were first run to assess the relationships between observed variables and solitary drinking. Next, SEM (Mplus, version 7; Muthén & Muthén, 1998–2012) was used to evaluate the measurement model and test the moderation hypothesis (Maslowsky, Jager, & Hemken, 2014; Tomarken & Waller, 2005). SEM was chosen because it is a highly flexible technique that considers multiple regressions simultaneously and reduces measurement error (Nachtigall, Kroehne, Funke, & Steyer, 2003).

Due to concerns about severe non-normality in the solitary drinking data, we treated this as a count dependent variable with a negative binomial distribution (Creswell, Bachrach, Wright, Pinto, & Ansell, 2016). For the measurement model, latent factors were estimated for 'Social Discomfort' and 'Drinking in Response to Negative Affect'. To test the moderation hypothesis, a baseline model was estimated, in which solitary drinking (percentage of time) was regressed simultaneously on the two latent constructs. Then, using a latent moderated structural equation estimation procedure (Klein & Moosbrugger, 2000), the moderation model was estimated in which solitary drinking was regressed on both latent constructs and an interaction term (i.e., 'Social

<sup>1</sup> Example items of the NIAAA alcohol consumption question set include: "During the past 12 months, how often did you usually have any kind of drink containing alcohol? Choose only one" and "During the past 12 months, how many alcoholic drinks did you have on a typical day when you drank alcohol?" Response options and endorsement frequencies for past year drinking behavior are included in the Supplementary material.

<sup>2</sup> All item measures were summed for a total score with the exception of the DMQ-R coping motives subscale in which items were averaged for a total score. In all cases, higher scores reflect greater endorsement of the construct.

<sup>3</sup> SEM analyses were rerun including only individuals who correctly completed all four attention checks ( $N = 383$ ), and results for both the baseline and moderation models remained the same.

discomfort'  $\times$  'Drinking in response to negative affect'), produced using the XWITH command in Mplus (Muthén & Muthén, 1998–2012).

The baseline and moderation models controlled for gender, age, ethnicity, past year alcohol quantity and frequency, and number of "attention checks" answered correctly.<sup>4</sup> For both models, factor loadings were freed and all latent variable variances were fixed at 1 so latent variables could be graphed in their own scales instead of the scale of any factor indicator (L.K., Muthén, 2016). All models were run using a robust maximum likelihood (MLR) estimator to generate a log likelihood value. These values were used to perform a log likelihood ratio test to compare the moderation model to the baseline model (Maslowsky et al., 2014).

Because traditional model fit indices in Mplus are not generated with count outcome variables, the baseline model was additionally run using a binary outcome variable of solitary (vs. social-only) drinking. Here, a weighted least squares means and variance (WLSMV) estimator was used to generate the Comparative Fit Index (CFI) and the Root Mean Square Error of Approximation (RMSEA) along with its confidence interval to assess model fit.

## 4. Results

Of the 660 participants who reported lifetime percentage of solitary drinking, 487 (73.8%) reported ever ( $> 0\%$ ) drinking alone. Among these solitary drinkers, the mean percentage of time spent drinking alone was 25.3% (SD = 28.34, median = 14.0%, range = 1–100%—see Supplementary Material).<sup>5</sup> Table 1 shows bivariate correlations between solitary drinking and observed variables across all participants, as well descriptive statistics.

Correlations between solitary drinking and observed variables were significant and in the anticipated direction with the exception of maximum quantity of drinks, which was non-significant. Specifically, increases in solitary drinking correlated with increases in AUDIT and B-YAACQ scores, social anxiety, loneliness, past year drinking quantity and frequency, frequency of past year maximum drinking quantity, drinking to cope motive endorsement, and decreases in perceived appraisal and belonging social support, drinking refusal self-efficacy for emotional relief, age of first drink, and age of first intoxication experience. Thus, as predicted, solitary drinking was associated with more alcohol problems, greater alcohol consumption, earlier age of alcohol involvement, greater social discomfort, and greater endorsement of drinking in response to negative affect.

### 4.1. Measurement model and baseline model

The measurement model demonstrated acceptable fit to the data,  $\chi^2(4) = 19.15$ ,  $p < 0.01$ ; RMSEA = 0.077, 90% confidence interval (CI) = 0.045–0.11; CFI = 0.98, Standardized Root Mean Square Residual (SRMR) = 0.03. The baseline model (see Fig. 1) showed a significant association between solitary drinking and 'Drinking in Response to Negative Affect' ( $b = 0.35$ , SE = 0.06,  $p < 0.001$ ) but not 'Social Discomfort' ( $b = 0.06$ , SE = 0.06,  $p = 0.37$ ). Factor loadings and the pattern of coefficients remained comparable when the model

<sup>4</sup> SEM analyses were also run with the following covariates added: the three other DMQ-R drinking motives (i.e., social, enhancement, and conformity), negative affect (measured by the PID-5 Negative Affectivity subscale; Krueger et al., 2013), employment status, and parents' highest education level as a proxy for socioeconomic status. Factor loadings and path coefficients were similar and the same pattern of significant and non-significant findings emerged.

<sup>5</sup> The percentage of solitary drinkers in this study is somewhat higher than previous studies on college students (e.g., Gonzalez et al., 2009; Gonzalez & Skewes, 2013). This is likely a function of different sampling strategies (e.g., we excluded alcohol abstainers, whereas prior studies tend to include these participants when estimating solitary drinking prevalence). However, the mean time spent drinking alone in the current study is comparable to prior studies (Creswell et al., 2014; Creswell, Chung, et al., 2015; Creswell, Wright, et al., 2015).

was rerun using the binary outcome of solitary drinking (to assess model fit). Of note, this model had good fit,  $\chi^2(7) = 22.04$ ,  $p < 0.01$ ; RMSEA = 0.057, 90% CI = 0.031–0.084; CFI = 0.98.

### 4.2. Moderation model

A moderation model was run in which 'Social Discomfort' moderated the relationship between 'Drinking in Response to Negative Affect' and solitary drinking (see Fig. 2). Using the log likelihood ratio test, the results supported that this model had improved fit over the baseline model,  $\chi^2(1) = 8.06$ ,  $p < 0.001$ . The main effect of 'Drinking in Response to Negative Affect' to solitary drinking remained significant ( $b = 0.46$ , SE = 0.09,  $p < 0.001$ ), while the main effect of 'Social Discomfort' to solitary drinking was again non-significant ( $b = 0.11$ , SE = 0.08,  $p = 0.17$ ). Notably, and as predicted, there was a significant interaction between 'Social Discomfort' and 'Drinking in Response to Negative Affect' on solitary drinking ( $b = -0.24$ , SE = 0.10,  $p = 0.01$ ).

Fig. 3 depicts this interaction. The logit link function (the default in Mplus) was used, since solitary drinking was modeled with a negative binomial distribution; as such, increases in the solitary drinking variable are in a logarithmic scale. Because it is difficult to interpret log scales, the betas generated from the separate slopes were exponentiated, transforming the scale into the rate mean (Long, 1997). Results can be interpreted as increases in the average percent of drinking time spent alone (i.e., solitary drinking). Contrary to the hypothesis, with every 1 SD increase in 'Drinking in Response to Negative Affect', solitary drinking increased by a factor of 2.01 for individuals 1 SD below the 'Social Discomfort' mean ( $e^{0.71}$ ), and 1.24 for individuals 1 SD above the 'Social Discomfort' mean ( $e^{0.22}$ ). That is, the relationship between 'Drinking in Response to Negative Affect' and solitary drinking was stronger for those lower in 'Social Discomfort' rather than higher in 'Social Discomfort'. The Johnson-Neyman (Johnson & Neyman, 1936) approach, which assesses significant regions along the continuum of the moderating variable (Bauer & Curran, 2005), indicated that the relationship between 'Drinking in Response to Negative Affect' and solitary drinking was significant across all values of 'Social Discomfort'.

## 5. Discussion

This study achieved the first aim of replicating findings that solitary drinking is associated with greater social discomfort, greater endorsement of drinking in response to negative affect, greater alcohol consumption, and more alcohol problems (Arpin et al., 2015; Buckner & Terlecki, 2016; Christiansen et al., 2002; Cooper, 1994; Cooper et al., 1992; Creswell et al., 2014; Creswell et al., 2015; Gonzalez et al., 2009; Gonzalez & Skewes, 2013; Tucker et al., 2006; Williams et al., 2015). Extending prior research, we also examined the simultaneous influence of social discomfort and drinking in response to negative affect on solitary drinking and found that social discomfort was not significantly associated with solitary drinking after accounting for drinking in response to negative affect. Contrary to prediction, the relationship between drinking in response to negative affect and solitary drinking was magnified by lower, rather than higher, social discomfort.

An important caveat should be mentioned when interpreting the current results. Although we considered individuals who scored "high" and "low" on the social discomfort construct to interpret the interaction, the sample as a whole reported substantially higher levels of loneliness and social anxiety and lower levels of social support compared to other samples (see Brown et al., 1997; Cacioppo et al., 2002; Cohen, McGowan, Fooskas, & Rose, 1984). Thus, participants who were "low" on social discomfort still experienced substantial social discomfort compared to other samples. This may be due to our recruitment strategy, as MTurk samples typically report levels of depression and anxiety at comparable rates to those endorsed by patients with mood and anxiety disorders (Arditte, Çek, Shaw, & Timpano, 2016).

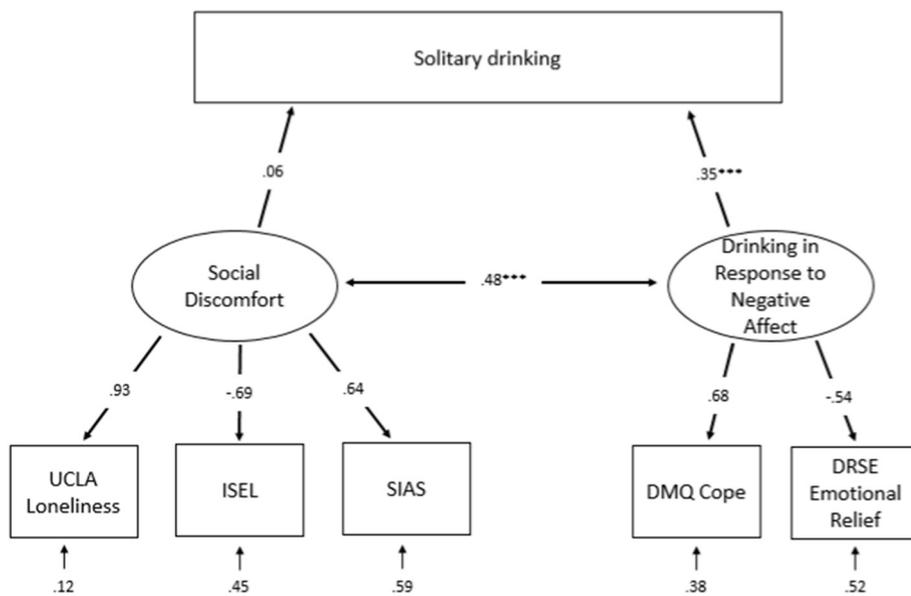


Fig. 1. Baseline model – Solitary drinking is significantly associated with ‘Drinking in Response to Negative Affect’, but not ‘Social Discomfort’. \*\*\* $p < 0.001$ . Note.  $N = 664$ . Covariates included were age, ethnicity, sex, past year quantity and frequency of alcohol consumption, and attention checks. All path coefficients are x-standardized and all factor loadings are significant at  $p < 0.001$ . Solitary drinking is the percent of time drinking spent alone. ISEL = Interpersonal Support Evaluation List (appraisal and belonging subscales); SIAS = Social Interaction Anxiety Scale; DMQ = Drinking Motives Questionnaire; DRSE = Drinking Refusal Self-Efficacy.

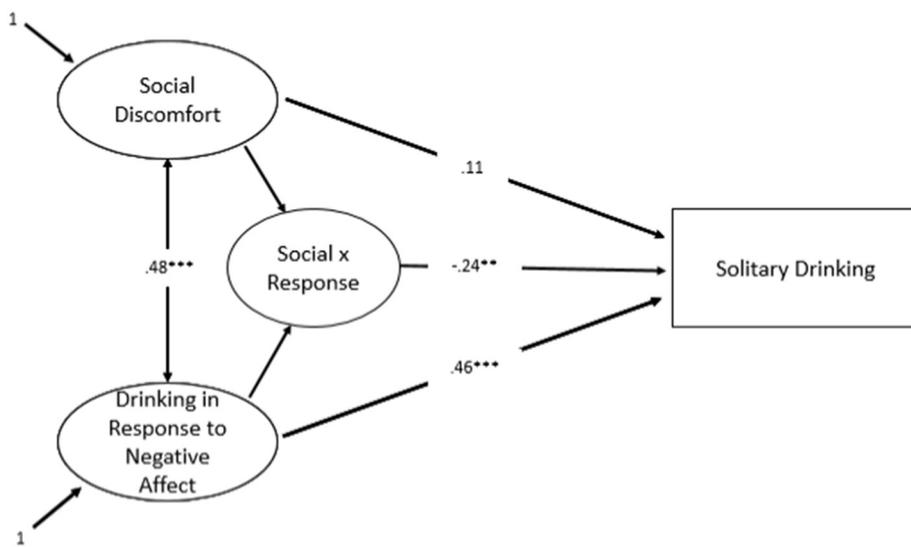


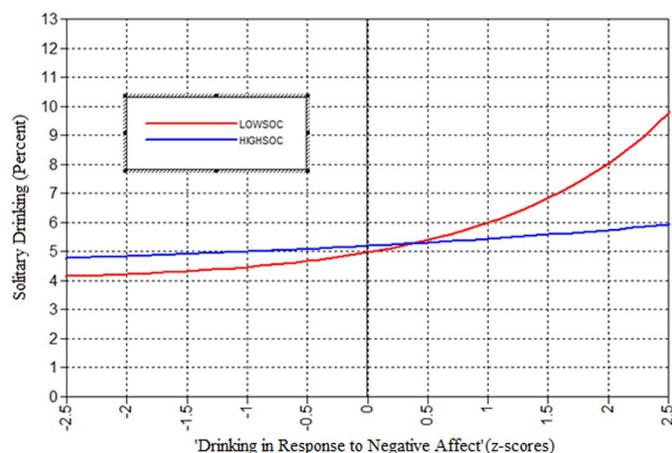
Fig. 2. Moderation model – The interaction between ‘Social Discomfort’ and ‘Drinking in Response to Negative Affect’ is significant. \*\* $p < 0.05$  \*\*\* $p < 0.001$ . Note.  $N = 664$ . Covariates included were age, ethnicity, sex, past year quantity and frequency of alcohol consumption, and attention checks. Path coefficients are in x-standardized form. Solitary drinking is the percent of time drinking spent alone.

Importantly, despite the significant interaction found here, the relationship between drinking in response to negative affect and solitary drinking was significant across all values of the social discomfort latent variable (i.e., for both those “low” and “high” on social discomfort). Studies that recruit participants with more variable social discomfort scores are indicated to further test whether the relationship between drinking in response to negative affect and solitary drinking is stronger in those with higher versus lower social discomfort scores.

One possible, though speculative explanation considering the above caveat, is that participants with lower social discomfort (i.e., greater social integration and support) also experience more negative social interactions. Though much of the literature supports an association between increased social support and generally greater positive outcomes (Cohen & Wills, 1985), research also suggests that negative social interactions are separable from social integration and support (Cohen, 2004) and may be additional sources of stress or negative affect (Abbey, Abrams, & Caplan, 1985; Cohen, 2004). In the context of the current study, if individuals who reported lower social discomfort also experience greater negative interpersonal interactions, it becomes less surprising that they may be more likely to drink in response to negative affect. This explanation might be particularly relevant given the high percentage of females in our sample. Prior research indicates that the

association between interpersonal conflict and solitary drinking is especially pronounced among females (Mohr et al., 2001). Thus, participants with lower social discomfort in the current study may also be more likely to experience negative interpersonal interactions, and to primarily handle these experiences by drinking alone. Alternatively, individuals with higher social discomfort might use alcohol in social situations to mitigate this discomfort and thus might not need to drink when alone. Future studies which include negative social interaction measures or explore more explicit reasons for drinking alone are needed to test these hypotheses.

The present study has limitations. Like most studies investigating solitary drinking, this is a cross-sectional survey which precludes drawing causal conclusions. Future studies should utilize prospective designs or social rejection/mood manipulations in controlled laboratory experiments to establish whether these constructs precipitate solitary drinking. Another limitation is the homogeneity of the sample. We restricted participation to 18 to 20 year old, though we chose this age range given that solitary drinking is particularly risky for younger individuals (Christiansen et al., 2002; Creswell et al., 2014; Gonzalez et al., 2009; Tucker et al., 2006). The majority of participants were also female, white, and in college. While these demographics are typical of most solitary drinking studies (e.g., Buckner & Terlecki, 2016;



**Fig. 3.** The relationship between 'Drinking in Response to Negative Affect' and solitary drinking is stronger for those with lower 'Social Discomfort'.

Note. "LOWSOC" represents 1 SD below the 'Social Discomfort' mean and "HIGHSOC" represents 1 SD above the 'Social Discomfort' mean. 'Drinking in Response to Negative Affect' is in z-scores reflecting a range from 2.5 SDs below the mean of 'Drinking in Response to Negative Affect' and 2.5 SDs above this mean. The slopes from 'Drinking in Response to Negative Affect' to solitary drinking have been exponentiated for both high and low 'Social Discomfort' simple slopes, allowing solitary drinking to be interpreted as the mean rate or increase in the average percent of drinking time spent alone.

Christiansen et al., 2002; Gonzalez, 2012; Gonzalez & Skewes, 2013; Keough et al., 2016; Williams et al., 2015) and common when using recruitment sites like MTurk (Berinsky, Huber, & Lenz, 2012), it may limit the generalizability of the findings. Indeed, the cultural and social contexts that dictate solitary drinking may be unique to this group [e.g., for women, drinking alone might be a safer way of drinking than accepting a potentially drugged drink from a stranger (see Bancroft, 2012)]. Future studies are needed to replicate these findings among more diverse samples.

Additionally, participants were asked to retrospectively recall the percent of time they drank alone since they began drinking, which may have introduced bias. Due to concerns about response burden, depression and anxiety measures (beyond social anxiety) were not included. Future work may want to assess these constructs to ascertain how psychopathology – more broadly – is related to solitary drinking. It is noteworthy, though, that results remained the same when controlling for the Negative Affectivity subscale of the PID-5 (Krueger, Derringer, Markon, Watson, & Skodol, 2013). Similarly, we were not able to compare drinking quantity consumed across solitary and social drinking contexts, but future studies should do so to further contextualize solitary drinking. Finally, on average, participants reported substantial social discomfort relative to other samples. It will be important to replicate our findings using community and college samples with more normative levels of social discomfort.

The present study also has several strengths. First, SEM allowed us to create latent variables and examine relationships between these and solitary drinking after correcting for random error and biases derived from such error (Tomarken & Waller, 2005). Additionally, we recruited a large sample of underage drinkers and controlled for both quantity and frequency of alcohol consumption, enabling us to investigate the relationships between specific constructs of interest, without variance attributable to general drinking habits. Our findings add to a growing literature indicating the risks of solitary drinking among youth. Results also include the novel finding that social discomfort no longer predicts solitary drinking, after accounting for drinking in response to negative affect. Finally, results indicate a counter-intuitive relationship between drinking in response to negative affect and solitary drinking. This relationship was stronger among those who reported lower, versus higher, social discomfort. These results present a new perspective on identifying individuals who may be more likely to drink alone, meriting

further study.

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## Contributors

Authors Kasey Creswell and Carillon Skrzynski designed the study and wrote the protocol. Carillon Skrzynski conducted literature searches, provided summaries of previous research studies, conducted the statistical analyses, and wrote the first draft of the manuscript. Authors Tammy Chung and Rachel Bachrach made valuable conceptual contributions throughout the study design process. All authors edited and have approved the final manuscript.

## Conflict of interest

All authors declare that they have no conflicts of interest.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.addbeh.2017.11.009>.

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