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Suggestibility is associated with alcohol self-administration, subjective alcohol effects, and self-reported drinking behavior

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Abstract

Background: Suggestibility, defined as an individual's inclination to accept and internalize messages, has not been studied in relation to alcohol use. Peer conformity, a component of suggestibility, may be related to alcohol use, as peer groups show similarities in patterns of alcohol use. Few studies have assessed how suggestibility and peer conformity relate to alcohol self-administration or to reinforcing effects of alcohol.

Aims: This study assessed whether suggestibility and peer conformity were associated with drinking behavior, alcohol self-administration, subjective response to alcohol, and drinking motives and expectancies.

Methods: Study 1 participants were alcohol drinkers ($n=20$), who completed a laboratory study of free-access intravenous alcohol self-administration. Study 2 participants were adolescents and young adults, age 14–25 ($n=150$), with lifetime alcohol use. Participants completed surveys of suggestibility and drinking patterns (Study 1 and 2), subjective alcohol effects (Study 1 only), and alcohol motives and expectancies (Study 2 only).

Results/outcomes: In Study 1, participants with higher levels of suggestibility self-administered more alcohol, and reported greater subjective alcohol effects. Peer conformity, though correlated with suggestibility, was not related to these measures. In Study 2, participants with higher suggestibility reported more alcohol consumption, higher drinking motives and alcohol expectancies. Peer conformity was not related to alcohol consumption, but was related to coping and enhancement drinking motives, and all expectancies measures.

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Supplemental Material

Supplemental material for this article is available online.

Conclusions/interpretation: Results indicate that suggestibility, beyond peer conformity, may be a critical factor to study when examining alcohol consumption behavior, and may provide insight into the development of alcohol use disorder.

Keywords

Alcohol; peer influence; suggestibility; alcohol response; self-administration

Introduction

Alcohol use disorder is a major public health concern, with a lifetime prevalence of nearly one in three adults in the USA (Grant et al., 2015). Chronic heavy alcohol drinking can lead to medical and psychiatric problems (Grant et al., 2015) as well as accidents, violence, and unsafe sexual behavior (White and Ray, 2014). Thus, it is critical to identify etiological factors that predict development of risky drinking so that high-risk individuals can be targeted for early intervention.

Suggestibility, or the degree to which an individual is automatically inclined to accept and internalize messages (Kotov et al., 2004), may be a risk factor for problematic drinking. Suggestibility is a multi-dimensional construct, comprised of several domains: consumer suggestibility (suggestibility to commercials, products), persuadability (changing one's mind based on other peoples' arguments), physiological suggestibility (feeling cold when someone else is shivering), physiological reactivity (feeling jumpy after watching a scary movie), and peer conformity (liking the same celebrities/fashion/music as friends) (Kotov et al., 2004). Suggestibility to messages or suggestions has been shown to influence a range of behaviors including emotion, sensations, cognition, and perception (Carhart-Harris et al., 2015). Suggestibility may even relate to clinical outcomes, as this trait has been shown to impact expectations of antidepressant treatment (Nitzan et al., 2015), raising the hypothesis that suggestible individuals may experience greater subjective effects of medical and non-medical recreational drugs. It is therefore possible that trait levels of suggestibility could impact the likelihood of an individual to self-administer substances such as alcohol, and even to impact an individual's perceptions of alcohol's subjective effects. No studies, to date, have tested whether individual differences in suggestibility explain variance in alcohol use patterns or subjective response to acute alcohol administration.

Although there have been no studies thus far on the broad construct of suggestibility and alcohol use, a handful of studies have examined how drinking behavior is related to social influence. Studies indicate that affiliation with drinking peers is one of the strongest determinants of alcohol use and misuse (Hawkins et al., 1992; Jacob and Leonard, 1994). Most alcohol drinking occurs in social settings, and members of peer groups generally show highly similar patterns of alcohol use with one another, likely due to a combination of selection and influence processes (Osgood et al., 2013). Most studies of alcohol drinking and peer influence investigate group comparisons of participants in various experimentally-controlled conditions. For example, in studies in which participants were exposed to either heavy drinking or non-drinking confederates, those exposed to heavy drinking confederates drank substantially more alcohol, both in the lab (Larsen et al., 2009) and in a real bar

setting (Larsen et al., 2012). Another study investigated the impact of social condition (alone vs. with others) on alcohol consumption, and found that individuals drank more alcohol when with others, and even drank more while alone immediately following a group drinking session (Kuendig and Kuntsche, 2012). Interestingly, although these studies have assessed how social influence affects alcohol use, they have not directly assessed the relationship between trait levels of peer conformity, one dimension of suggestibility, and alcohol use.

In the current study, we conducted two experiments to assess how trait levels of suggestibility, as well as its subcomponent of peer conformity, were related to alcohol self-administration, subjective alcohol responses, drinking motives, and expectancies from alcohol. In Study 1, we examined how suggestibility and peer conformity relate to alcohol self-administration in a laboratory setting. To do so, we used the Computerized Alcohol Infusion System (CAIS), which employs a physiologically based pharmacokinetic (PBPK) model-based algorithm (Ramchandani et al., 1999) to ensure that all participants achieved the same exposure level per intravenous (IV) infusion (Zimmermann et al., 2008, 2013). This IV method of administration allows the experimenter to remove typical social and alcohol cues, to better isolate the pharmacological effects of alcohol. Laboratory models of controlled alcohol exposure have been used extensively to identify predictors of alcohol consumption behaviors (Gowin et al., 2017; Stangl et al., 2017; Zimmermann et al., 2009), and these paradigms have been widely used to examine individual differences in the subjective effects of alcohol (Gilman et al., 2012; Hendershot et al., 2015). Rates of IV alcohol consumption, as defined as reaching a binge-level of exposure, have been associated with risk factors for alcohol use disorder (Gowin et al., 2017). To our knowledge, no laboratory self-administration studies have investigated whether self-reported suggestibility or peer conformity are associated with alcohol self-administration or with subjective alcohol responses. By conducting these studies in individuals in isolation from peers, we were able to isolate the relationship of trait-levels of suggestibility and peer conformity with alcohol self-administration and pharmacological alcohol responses, without confounding these traits with overt peer pressure.

In Study 2, we examined how suggestibility and peer conformity relate to self-reported alcohol drinking behavior, alcohol expectancies, and motives for drinking. We examined these measures in a community-based sample of adolescents and young adults, aged 14–25 years, with lifetime alcohol use. Adolescence, or the transitional period between childhood and adulthood, is a critically important age to study with regards to attitudes and behaviors regarding alcohol. Youth who begin drinking before age 15 years have 4–6 times the rate of lifetime alcohol dependence than those who remain abstinent from alcohol use until age 21 years (Grant and Dawson, 1997; SAMSHA, 2014), and the majority of adults who have an alcohol use disorder started using before age 18 years, and develop their disorder by age 20 years. Adolescence is also a critically important age in which to study suggestibility and peer conformity, as it has been shown that this is a period in which peer opinions become especially salient (e.g. Guyer et al., 2014; Masten et al., 2009; Pfeifer et al., 2011; Welborn et al., 2016). Therefore, we sought to examine whether, in a community sample of adolescents and young adults, suggestibility and peer conformity would relate to self-reported drinking behavior, attitudes, and expectancies.

We hypothesized that trait-level suggestibility, and its subdomain peer conformity, would be associated with (a) IV alcohol self-administration and subjective responses in a laboratory setting in adult drinkers (Study 1), and (b) self-report of recent drinking behavior, drinking motives, and alcohol expectancies among adolescents and young adults (Study 2). Examining these constructs may lead to a greater understanding of how variance in alcohol behavior is specific to trait levels of peer conformity, or more generally related to the broader personality construct of suggestibility. If suggestibility and peer conformity are related to alcohol use behaviors, these factors could provide insight into development and treatment of alcohol use disorders.

Materials and methods

Intravenous alcohol self-administration (IV-ASA) study (Study 1)

Participants.—The IV-ASA study included 20 community- recruited participants, ages 21–45 years of age, and was conducted at the Clinical Center of the National Institutes of Health (NIH; Bethesda, MD, USA) as part of a larger study examining the influence of personality and other factors and self-administration of alcohol. Analyses presented in the current article include the subset of participants from the parent project with available data on suggestibility (see below). All participants gave written informed consent to this study, which was approved by the NIH Addictions Institutional Review Board. See Table 1 for descriptive information.

Participants were medically healthy (no current or prior history of any central nervous system, cardiovascular, respiratory, gastrointestinal, hepatic, renal, endocrine, or reproductive disorders; no positive hepatitis or HIV test at screening), and had no current psychiatric disorders (including alcohol use disorders), verified by the Structured Clinical Interview for DSM-IV (SCID-IV); (First, 2002). In addition, participants reported drinking five or more drinks on at least one occasion in their lifetime.

Experimental protocol.—The study involved two in-person study visits: a screening visit and the IV-ASA study visit, which is described in detail in (Stangl et al., 2017). Please refer to Figure 1 for a summarized timeline of all procedures. Participants were required to abstain from alcohol for 48 h before the IV-ASA study day. On arrival at the IV-ASA study day, a breathalyzer test was performed to ensure a zero breath alcohol concentration (BrAC). A urine sample was collected for a drug screen for all participants and a beta-human chorionic gonado-tropin test for females; both were required to be negative to continue participation in the study. Participants received a light snack and completed brief medical and drinking history questionnaires. An IV catheter for alcohol infusion was then inserted into a vein in the antecubital fossa of (preferably) the nondominant arm using sterile technique. Participants were told to administer alcohol as if they were in a social situation in which they usually drink alcohol. To control the ambient environment during the self-administration session, participants could watch television or listen to music. The experimenter was available to monitor the infusion and obtain breathalyzer readings (Alcotest 6510 handheld breathalyzer; Draeger Safety Diagnostics, Irving, Texas, USA) approximately every 15 min.

The IV-ASA experiment consisted of a priming and a voluntary free-access phase. During the priming phase (first 25 min), participants were prompted to push a button to receive four small standardized alcohol infusions resulting in an estimated blood alcohol concentration (BAC) level of ~30 mg% at 10 min for all participants. This phase allowed participants to practice pushing the button for an infusion and to give them the opportunity to experience the effects of IV alcohol. This was immediately followed by a 125-minute voluntary free-access phase where participants could press the button for alcohol infusions whenever they chose. To minimize demand characteristics, participants were explicitly told that they were not obligated or incentivized to press for any alcohol infusions. The infusion rates were individually determined using the participants' age, height, weight and gender in a physiologically based pharmacokinetic model (Ramchandani et al., 1999), and implemented using the Computerized Alcohol Infusion System (Plawecki et al., 2007). Each button press resulted in a 7.5 mg% increase in estimated BAC at a fixed rate of 3 mg% per minute for a fixed duration of 2.5 min followed by a 1 mg% decrease per minute until the next button press. The button was inactivated (with participants' knowledge) if the next push exceeded the pre-set upper limit for estimated BAC exposure (100 mg%).

At the end of the free-access phase, the infusion pump was disconnected and the IV catheter was removed from the participant's arm. Participants were asked to stay in the hospital for at least two hours after the end of the self-administration or until their BrAC level fell below 20 mg%. The total duration of the session was approximately seven hours.

Measures.—On the day of the IV-ASA study visit, participants completed the following assessments:

Timeline Followback (TLFB; Sobell and Sobell, 1992).: Before initiation of the alcohol session, participants completed a 90-day TLFB interview, which was used to quantify number of drinking days as well as total drinks consumed in the past 90 days.

Multidimensional Iowa Suggestibility Scale (MISS; Kotov et al., 2004).: This scale was administered on the day of the test session prior to baseline procedures and assessed suggestibility in five domains: consumer suggestibility (suggestibility to commercials, products), persuadability (changing one's mind based on other peoples' arguments), physiological suggestibility (feeling cold when someone else is shivering), physiological reactivity (feeling jumpy after watching a scary movie), and peer conformity (liking the same celebrities/ fashion/music as friends). The individual domain subscales scores were summed to compute a total suggestibility score ranging from 64–320. Higher scores indicate higher overall suggestibility. Scores on the peer conformity sub-score (range: 14–70) and overall suggestibility measure were separately considered.

Drug Effects Questionnaire (DEQ; Fischman and Foltin, 1991).: This questionnaire was collected to assess five subjective effects of alcohol, including how much participants “feel” the effects of alcohol, “like” the effects, would like “more” of what they received, felt “high,” and felt “intoxicated.” This measure was collected on the test session day at baseline as well as during the priming phase (at the 10- and 20-minute time points), and eight additional times during the IV-ASA free access session every 15 min, with a final post-

infusion measure 15 min after the IV-ASA session had ended. Responses to each of the five questions ranged from 0–100%. The DEQ took approximately two minutes to complete, and participants could press for more alcohol during data collection to not interfere with self-administration.

Statistical analysis.—IV alcohol self-administration measures were calculated during the first 30 min of the free-access session (i.e. “ascending limb”), which occurred following a 25-minute priming phase. Behavior in the first 30 min of free access sessions has been shown to capture maximum variability in behavior (Stangl et al., 2017), and the ascending limb has been shown to be particularly sensitive to a positive association between stimulation and craving during acute alcohol exposure (Hendershot et al., 2015). We calculated the estimated average BAC (mg%) and the estimated peak BAC (mg%) as well as the number of button presses to receive alcohol. We also calculated peak subjective response measures from the DEQ of “Feel,” “Like,” “Want,” “High,” and “Intoxicated.”

Partial correlations were conducted to assess relationships among the Total Suggestibility Score on the MISS, alcohol self-administration behavior, and subjective responses to alcohol on the DEQ. Since DEQ ratings are highly dependent on alcohol tolerance (Gilman et al., 2012), analyses controlled for alcohol drinking history (number of drinks in the past 90 days; TLFB), as well as for age and sex. Separate partial correlations were conducted between the Peer Conformity subscale of the MISS and each of these measures. Analyses were conducted using SPSS, Version 19.0 (IBM Corporation, New York, USA) and the level of significance for all analyses was set at $p \leq 0.05$. Resulting p values were corrected for multiple comparisons (for eight tests: five DEQ variables during the free-access phase, and average BAC, peak BAC, and number of button presses) using a Benjamini-Hochberg correction (Benjamini, 1995).

Adolescent and young adult study (Study 2)

Participants.—Study 2 was conducted at the Center for Addiction Medicine at Massachusetts General Hospital (Boston, Massachusetts, USA) as part of a larger study on adolescent cannabis use and cognition. Data were available from a sample of 150 adolescents and young adults (76 males, 74 females), ages 14–25 years, who all reported at least one lifetime drinking occasion and who had suggestibility data available for the secondary analyses presented in the current manuscript. Eighty-one percent ($n=121$) of the participants analyzed in this secondary analysis also used cannabis weekly or more, and the remaining 29 participants were naïve to cannabis use. Participants were not excluded for current DSM-IV psychiatric disorders, but were excluded if they had any severe developmental delays, including but not limited to autism spectrum disorder, intellectual disability, and Down’s syndrome. Participants were recruited through advertisements in the community and on the Internet and through peer referral. Participants gave written informed consent to this study (or parental consent if under the age of 18 years), and the protocol was approved by the Partners Human Research Committee Institutional Review Board. See Table 1 for descriptive information.

Measures.—Recent drinking history was assessed using a 90-day TLFB (Sobell and Sobell, 1992), which assessed drinking days as well as total drinks in the past 90 days. In addition to the MISS described in Study 1, participants also completed the following questionnaires:

Brief Comprehensive Effects of Alcohol Questionnaire (BCEOA; Ham et al., 2005). The BCEOA is a 15-item self-report measure that assesses individuals' positive and negative alcohol expectancies. It comprises four subscales: Liquid Courage (e.g. feeling brave and daring), Change in Self-Perception (e.g. feeling guilty or moody), Sexual Experiences (e.g. feeling like a better lover or enjoying sex more), and Tension Reduction (e.g. feeling peaceful or calm). Participants rate the likelihood of experiencing each of the possible alcohol effects using a four-point Likert scale that ranges from "Disagree" to "Agree." Higher scores in each subscale indicate stronger effect of alcohol in each domain.

Drinking Motives Questionnaire, Revised (DMQ-R; Kuntsche and Stewart, 2009). The DMQ-R measures four motivational dimensions for alcohol use, including Social Motives (e.g. drinking to be sociable, to celebrate parties), Coping Motives (e.g. drinking because it makes you forget about problems), Enhancement Motives (e.g. drinking to feel better or to be able to do things otherwise impossible), and Conformity Motives (e.g. drinking because others do, to fit in). Participants rate how frequently they drink for each motive using a five-point Likert scale that ranges from "almost never/never" to "almost always/always." Higher scores indicate higher motivations for drinking in each subscale.

Statistical analysis.—Partial correlations were conducted to assess relationships among the Total Suggestibility Score on the MISS, and (a) drinking measures including TLFB (total drinks in the past 90 days, total drinking days in the past 90 days); (b) alcohol expectancies on the BCEOA (Liquid Courage, Self-Perception, Sexual Experiences, and Tension Reduction), (c) drinking motives on the DMQ-R (Social, Coping, Enhancement, and Conformity). All analyses controlled for age and sex. Separate partial correlations were conducted between the Peer Conformity subscale and these measures. Analyses were conducted using SPSS, Version 19.0 (IBM Corporation, New York, USA). The level of significance for all analyses was set at $p \leq 0.05$. Resulting p values were corrected for multiple comparisons (for 10 measures: two drinking variables, four BCEOA measures, four DMQ-R measures) using a Benjamini-Hochberg correction (Benjamini, 1995).

Results

IV-ASA study (Study 1)

During the first 30 min of the free-access phase, the average estimated BAC was 23.7 mg% (standard deviation (SD)=9.8 mg%), and the average peak estimated BAC was 34.4 mg% (SD=16.5 mg%). The average number of button presses for alcohol in the first 30 min was 5.0 (SD=2.6). All bivariate correlations between measures (e.g. peak BAC, average BAC, button presses, and the five DEQ responses) were significant at $p < 0.01$ (range of $r = 0.58$ – 0.97) (see Supplementary Material Table 1 for all correlations).

After controlling for drinking history (number of drinking days in the past 90 days), age, and sex, greater suggestibility predicted greater average estimated BAC (Pearson's $r=0.60$, $p=0.01$), greater peak BAC (Pearson's $r=0.54$, $p=0.03$), and a greater number of button presses (Pearson's $r=0.59$, $p=0.02$) (Figure 2(a)). These variables remained significant after corrections for multiple comparisons (Supplementary Material Table 1).

After controlling for alcohol drinking history, age and sex, greater suggestibility predicted greater scores on "Feeling the effects of alcohol" (Pearson's $r=0.52$, $p=0.04$), "Liking the effects of alcohol" (Pearson's $r=0.63$, $p=0.01$), "feeling high" (Pearson's $r=0.54$, $p=0.03$), and "feeling intoxicated" (Pearson's $r=0.54$, $p=0.03$) (Figure 2(b)). There was a no association between suggestibility and "Wanting more" (Pearson's $r=0.22$, $p=0.22$).

Total suggestibility was highly correlated with peer conformity (Pearson's $r=0.75$, $p<0.001$). However, in contrast to total suggestibility, the peer conformity subscale did not correlate with any measure tested (all p values >0.1 , Pearson's r range $=0.07-0.40$).

Adolescent and young adult study (Study 2)

Greater suggestibility predicted more drinking days in the past 90 days (Pearson's $r=0.28$, $p=0.01$), and a greater number of drinks in the past 90 days (Pearson's $r=0.23$, $p=0.03$) (Figure 3(a)). Greater suggestibility also predicted greater alcohol expectancies, including liquid courage (Pearson's $r=0.30$, $p=0.01$), altered self-perception (Pearson's $r=0.26$, $p=0.02$), and tension reduction (Pearson's $r=0.28$, $p=0.01$) (Figure 3(b)). Suggestibility did not predict expectancies of sexual experiences (Pearson's $r=0.14$, $p=0.22$). Finally, greater suggestibility predicted each of the four motivational dimensions for alcohol use: social motives (Pearson's $r=0.31$, $p=0.004$), coping (Pearson's $r=0.35$, $p=0.001$), enhancement (Pearson's $r=0.23$, $p=0.03$), and conformity (Pearson's $r=0.35$, $p=0.001$) (Figure 3(c)). After Benjamini-Hochberg correction (Benjamini, 1995), all correlations remained significant. See Supplementary Material Table 2 for all correlations among outcome variables.

Total suggestibility was highly correlated with peer conformity (Pearson's $r=0.71$, $p<0.001$). However, peer conformity, compared to total suggestibility, was not associated with drinking days in the past 90 days or with a greater number of drinks in the past 90 days (all p values >0.05). Peer conformity predicted two motivational dimensions for alcohol use: coping (Pearson's $r=0.33$, $p=0.002$), and enhancement (Pearson's $r=0.23$, $p=0.03$). Peer conformity did not correlate with conformity, nor social drinking motives (p values >0.05). Finally, as with total suggestibility, greater peer conformity predicted greater alcohol expectancies, including liquid courage (Pearson's $r=0.24$, $p=0.03$), expectancies of sexual experiences (Pearson's $r=0.23$, $p=0.04$), and tension reduction (Pearson's $r=0.36$, $p=0.001$) (Figure 3(b)). Peer conformity did not predict altered self-perception (Pearson's $r=0.11$, $p=0.30$).

Discussion

These studies together demonstrate that trait-level suggestibility may be an important determinant of alcohol consumption, as demonstrated in laboratory IV self-administration behavior and subjective alcohol effects (Study 1), and is associated with self-reported alcohol drinking patterns, including drinking days, motives, and expectancies (Study 2). Peer

conformity, though highly correlated with suggestibility, does not appear to be directly related to alcohol self-administration or to self-reported drinking behavior (Study 1), or to self-reported drinking patterns (Study 2).

No studies, to date, have examined the relationship between self-reported measures of trait-level suggestibility and self-administration of alcohol, subjective alcohol effects, or self-reported drinking behavior. Although studies have shown that individuals choose peer groups based on shared norms (e.g. people tend to affiliate with peers whose drinking behavior matches their own) (Crosnoe and McNeely, 2008), it is difficult to determine an independent role for inherent trait-level measures of suggestibility. In Study 1, suggestibility was associated with the acute reinforcing properties of alcohol, as well as alcohol administration behavior, even after controlling for drinking history. Participants with higher suggestibility scores self-administered more alcohol, and reported greater effects for “Feel,” “High,” “Like,” and “Intoxicated.” We hypothesized that peer conformity, a subdomain of suggestibility, could potentially be important in understanding the link between suggestibility and alcohol intake. However, we did not find that peer conformity correlated with these measures. This indicates that perhaps other subcomponents of suggestibility, including consumer suggestibility, persuadability, physiological suggestibility, and physiological reactivity, may be more prominent risk factors of alcohol consumption. Since this is a small study ($n=20$), we did not correlate each subcomponent of suggestibility with each alcohol measure, but additional studies with larger samples are underway to examine this issue more comprehensively.

Though previous studies have not assessed how suggestibility affects subjective alcohol effects, there is a large literature showing that those who report greater sensitivity to the stimulant and rewarding effects of alcohol progress toward more symptoms of alcohol use disorder (e.g. (King et al., 2014)). Previous research has shown that altered sensitivity to alcohol’s rewarding effects are associated with heavier drinking and increased risk for alcohol dependence (King et al., 2011, 2014), indicating that heightened sensitivity to the stimulant effects of alcohol may be part of an enhancement pathway to drinking. Study 1 demonstrates that individuals with greater levels of suggestibility are also more sensitive to alcohol, suggesting that motives for drinking (i.e. drinking to facilitate social interactions or to conform with social expectations; (Cooper, 1994)), and drinking for internal rewarding states (e.g. pharmacological effects of alcohol) may be linked. Of note, efforts to examine the relationship between personality characteristics and the dopaminergic system have shown that striatal $D_{2/3}$ receptor availability is linked with socially desirable responding, particularly social conformity (Egerton et al., 2010), indicating that a biological pathway may mediate this relationship. Furthermore, family history of alcoholism has also been associated with striatal $D_{2/3}$ receptor availability and subjective response (Alvanzo et al., 2017), perhaps suggesting that that greater levels of suggestibility, and its biological underpinnings, may be linked to increased risk for alcohol use disorders. Though speculative, larger studies could potentially examine biological moderators of suggestibility and alcohol response.

Study 2 found significant relationships among self-reported suggestibility and (a) drinking patterns in the past 90 days, (b) social, coping, enhancement, and conformity-related motives

to drink, and (c) liquid courage, altered self-perception, and tension-reduction alcohol expectancies. In contrast, the peer conformity subdomain did not correlate with drinking patterns in the past 90 days, though it did relate to some, but not all, drinking motives and expectancies. Few studies have attempted to discriminate between mechanisms of influence, though one observational study of alcohol drinking and peer influence found that peer modelling (imitating others' drinking), and not overt persuasion, significantly influenced individual drinking (Bot et al., 2007). Another study found that peer pressure and peer conformity measures were stronger predictors of risk behavior, including alcohol use, than was popularity, general conformity, or dysphoria (Santor et al., 2000). The current study suggests that mechanisms underlying drinking behavior may be somewhat variable across individuals with different trait levels of suggestibility, and, as in Study 1, the general trait of suggestibility may be a more prominent risk factor of alcohol consumption than peer conformity alone.

There are limitations to this study. Both Study 1 and Study 2 are cross-sectional, so we cannot determine whether suggestibility was a causal factor in alcohol use. Study 1, with 20 participants, is small and, therefore, we did not have the power to investigate sub-groups by age, gender, or other potential moderators (though analyses controlled for these factors). These small sample sizes in both studies precluded us from examining relationships between other suggestibility dimensions (consumer suggestibility, persuadability, physiological suggestibility, and physiological reactivity). Additionally, in Study 2, 81% of participants were weekly or more cannabis users, and therefore we cannot rule out the influence of cannabis on the relationship between suggestibility and alcohol use.

Another potential limitation is the issue of whether suggestibility was inherently linked to other compliance-related self-report factors, such as whether or not participants were concerned with social approval during the experiment. Though participants in the IV-self administration study were not incentivized in any way based on the amount of alcohol self-administration, we did not specifically assess for differences in compliance-related self-report factors or image management more generally. We acknowledge the relationship between suggestibility and social desirability (Latkin et al., 2017) as well as social conforming and image management (Mosher Ruiz et al., 2017). Therefore, we recommend that future studies prospectively recruit individuals who are high and low on trait suggestibility and assess drinking behavior in controlled social settings (e.g. examine effects of suggestibility on modeling of a confederate's drinking behavior) (Dallas et al., 2014; Larsen et al., 2012; Robinson et al., 2016). Additionally, in Study 1 there was no IV placebo control condition. Therefore, we were not able to isolate the contribution of expectancies from the pharmacological effects of alcohol. Future studies could include a placebo control when examining the influence of suggestibility on self-administration to further explore this relationship.

Finally, though this is a study on suggestibility, peer conformity, and alcohol administration, all administration procedures in Study 1 occurred while the participants were alone. We contend that this strengthens our findings, as this paradigm allows us to examine associations between reported suggestibility and hedonic response to alcohol, without non-pharmacological cues from actual peers. However, future studies could investigate whether

testing groups of participants together amplifies the effects observed in this study, and if subjective perceptions of alcohol and hedonic response change amongst peers and influence self-administration behavior.

In conclusion, few studies have investigated the relationship between suggestibility, drinking motives and expectancies, and alcohol consumption and associated subjective effects. Our findings indicate that suggestibility, and to a lesser extent peer conformity, may be an important factor when examining alcohol consumption behavior, and may provide insight into harmful drinking behavior such as binge drinking. Reducing peer conformity has been a primary component of many adolescent prevention and treatment programs (Larimer and Cronce, 2007), and a recent study suggests that those who are most susceptible to peer influence and have heavier-drinking friends receive the most benefit from these types of interventions (Hallgren et al., 2017). Thus, there is a need for research that examines the link between suggestibility, social drinking motives, and subjective effects of alcohol, including indices of alcohol reinforcement such as liking and wanting, which are central to neurobiological theories of addiction (Robinson and Berridge, 1993).

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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IV- Alcohol Administration Study Session Timeline

Time Point	Questionnaires
Screening Visit (previous to study)	SCID-IV, TLFB
Pre-Run	MISS
Baseline	DEQ
0, 25	No Questionnaires
10-165	DEQ

Figure 1.

This timeline demonstrates the structure, timepoints and questionnaires given during the intravenous (IV)-self administration study (Study 1).

DEQ: Drug Effects Questionnaire; MISS: Multidimensional Iowa Suggestibility Scale; SCID-IV: Structured Clinical Interview for DSM-IV; TLFB: Timeline Followback.

(a) Alcohol Administration Behavior

(b) Subjective Alcohol Effects during Open-Access Phase

Figure 2.

(a) After controlling for drinking history, greater suggestibility predicted greater average estimated blood alcohol concentration (BAC), greater peak BAC, and a greater number of button presses. (b) After controlling for alcohol drinking history, greater suggestibility predicted greater scores on each of the Drug Effects Questionnaire (DEQ) measures, with a trend-level effect for "want more." Residuals of each measure after controlling for age and sex, are graphed. Dotted lines represent the 95% confidence interval of the linear regression line.

(a) Self-Reported Drinking Behavior **(b) Self-Reported Alcohol Expectancies** **(c) Self-Reported Alcohol Motives** **Figure 3.**

(a) Greater suggestibility predicted more drinking days in the past 90 days, and more drinks in the past 90 days; (b) greater suggestibility predicted greater alcohol expectancies, including liquid courage, altered self-perception, and tension reduction; (c) greater suggestibility predicted greater scores on social motives, coping, enhancement, and conformity motives. Residuals of each measure after controlling for age, sex, and drinking history are graphed. Dotted lines represent the 95% confidence interval of the linear regression line.

BCEOA: Brief Comprehensive Effects of Alcohol Questionnaire; DMQ: Drinking Motives Questionnaire.

Table 1.

Participant particulars.

	Study 1 (n=20)	Study 2 (n=150)
Demographics		
Age	25.5 (5.4)	19.9 (2.4)
Years of education	16.3 (2.2)	12.7 (2.2)
Gender (% male)	30%	50.7%
Ethnicity		
Hispanic or Latino	20.0%	6.0%
Not Hispanic or Latino	80.0%	94.0%
Race		
American Indian or Alaska Native	0.0%	0.0%
Asian	15.0%	4.7%
Black or African American	25.0%	13.3%
Native Hawaiian or other Pacific Islander	0.0%	0.67%
White	60.0%	68.0%
Multiracial	0.0%	8.0%
Unknown or not reported	0.0%	5.33%
Lifetime drug/alcohol use		
Total drinks in past 90 days	102.7 (86.9)	Mdn: 48.5 IQR: 10.0–99.0
Drinking days in past 90 days	23.0 (15.5)	Mdn: 12.0 IQR: 4.0–24.0
DMQ		
Social motives	N/A	3.4 (0.9)
Coping	N/A	1.9 (0.8)
Enhancement	N/A	2.9 (0.9)
Conformity	N/A	1.3 (0.4)
Total	N/A	9.5 (2.3)
MISS		
Consumer suggestibility	21.5 (5.9)	20.2 (5.7)
Persuadability	42.7 (10.1)	41.4 (7.9)
Physiological suggestibility	19.2 (5.2)	20.8 (5.9)

	Study 1 (n=20)	Study 2 (n=150)
Physiological reactivity	44.3 (6.9)	41.3 (7.5)
Peer conformity	42.7 (8.0)	27.9 (9.1)
Suggestibility total	170.3 (27.5)	151.7 (24.9)
BCEOA		
Liquid courage	N/A	3.0 (0.6)
Self-perception	N/A	2.5 (0.7)
Sexuality	N/A	2.6 (0.8)
Tension	N/A	2.9 (0.7)

AUDIT: Alcohol Use Disorders Identification Test; BCEOA: Brief Comprehensive Effects of Alcohol; DMQ: Drinking Motives Questionnaire IQR: interquartile range; mdn: median; MISS: Multidimensional Iowa Suggestibility; TLFB: Timeline Followback (past 90 days).

Note: all values are means (standard deviations), unless otherwise noted as sample percentages or mdns and IQRs. BCEOA was available for 97 participants, DMQ was available for 140 participants.