Susceptibility to Social Influence is Associated with Alcohol Consumption and Subjective Alcohol Effects

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**Abstract**

**Background and Aims**: Most alcohol drinkers predominantly drink in social settings, and members of peer groups generally show high similarities in patterns of alcohol use with one another. These social reasons for drinking are accompanied by motives driven by internal states, including an individual’s sensitivity to the reinforcing pharmacological effects of alcohol. However, these two orthogonal factors-- susceptibility to social influence and subjective response to alcohol—have not been studied together.

**Design and Setting**: In Study 1, conducted at Massachusetts General Hospital, we examined whether susceptibility to influence was associated with real-world drinking outcomes. In Study 2, conducted at the National Institute on Alcohol Abuse and Alcoholism, we investigated whether susceptibility to influence was associated with laboratory self-administration of intravenous alcohol and subjective response to intravenous alcohol.

**Participants**: In Study 1, participants were 90 young adults, aged 16-25 years, who reported any prior alcohol use. In Study 2, participants were 20 adults, aged 22-43 years, all of whom reported ever drinking five or more drinks on one occasion.

**Measurements**: In Study 1, susceptibility to social influence. drinking patterns, alcohol expectancies, and alcohol motives were measured via self-report questionnaires. In Study 2, self-administration of intravenous alcohol during the human laboratory session was recorded, and subjective response to intravenous alcohol was measured by self-report.

**Findings**: In Study 1, individuals who were more susceptible to influence consumed more alcoholic drinks in the past 90 days, and showed higher motives and expectancies from alcohol. In Study 2, individuals who were more susceptible to influence showed greater rates of alcohol self-administration, and greater subjective effects of alcohol (feeling effects, wanting more, feeling high, and feeling intoxicated), even after controlling for drinking history.

**Conclusion**: Results indicate that susceptibility to social influence may be a critical factor to study when examining alcohol consumption behavior, and may provide insight into the development of alcohol use disorder.

**Introduction**

Alcohol use disorder is a major public health concern, with a lifetime prevalence of nearly one in three individuals in the United States (Grant et al., 2015). Chronic heavy alcohol drinking can lead to chronic medical and psychiatric problems such as brain impairment and medical consequences (Grant et al., 2015). Excessive acute consumption such as binge drinking can also lead to adverse consequences such as accidents, violence, and unsafe sexual behavior (White & Ray, 2014). Thus, it is critical to identify etiological factors predict development of risky drinking so that individuals can be targeted for early intervention.

Affiliation with drinking peers is one of the strongest determinants of alcohol use and misuse (Hawkins, Catalano, & Miller, 1992; Jacob & 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). Studies have reported positive relationships between susceptibility to influence and hazardous drinking (Santor, Messervey, & Kusumakar, 2000), as well as to other delinquent behavior (Miller, 2010). However, studies have not yet investigated whether susceptibility to social influence is associated with self-administration of alcohol in a controlled laboratory setting, or with subjective effects of alcohol, both of which have been shown to be predictors of developing alcohol use disorders (King, de Wit, McNamara, & Cao, 2011; King, McNamara, Hasin, & Cao, 2014; Kuntsche, Knibbe, Gmel, & Engels, 2005).

Laboratory models of alcohol exposure are well suited to identify predictors of alcohol consumption behaviors, including susceptibility to social influence, and these paradigms have been widely used to examine individual differences in the subjective effects of alcohol (Gilman, Ramchandani, Crouss, & Hommer, 2012; Hendershot et al., 2015). Previous research indicates that low sensitivity to alcohol’s sedative effects and high sensitivity to alcohol’s stimulant effects are associated with heavier drinking and increased risk for alcohol dependence (King et al., 2011; King et al., 2014; Schuckit, 1994). Additionally, human laboratory models of intravenous alcohol self-administration (IV-ASA) have been developed to examine determinants of alcohol seeking and consumption behavior (Zimmermann, O'Connor, & Ramchandani, 2013). Recent work has demonstrated that IV-ASA is associated with drinking history and alcohol expectancies (Stangl et al., 2017), and rates of IV alcohol consumption were associated with risk factors for alcohol use disorder (Gowin, Sloan, Stangl, Vatsalya, & Ramchandani, 2017).

The present study examined whether susceptibility to social influence was associated with (1) self-report of real-world drinking behavior, drinking motives, and alcohol expectancies among young adults (Study 1); and (2) IV alcohol self-administration and subjective responses in a laboratory setting (Study 2). We hypothesized that greater susceptibility to social influence would be associated with (1) heavier self-reported drinking, greater drinking motives, and greater alcohol expectancies; and (2) greater amounts of self-administered alcohol, and greater reported acute subjective effects to alcohol in a laboratory setting.

**Materials and Methods**

**Young Adult Study (Study 1).**

Participants: Study 1 study was conducted at the Center for Addiction Medicine at Massachusetts General Hospital (Boston, MA) as part of a larger study on young adult cannabis use and cognition. Data were available from a sample of 90 young adults (45 men, 45 women), ages 16-25 years, who all reported at least one lifetime drinking occasion. Participants were recruited through advertisements in the community, by email, web, and bulletin board announcements posted within the local network community. Participants gave written informed consent to this study (or parental consent if under the age of 18), which was approved by the Partners Human Research Committee Institutional Review Board. See Table 1 for descriptive information.

Protocol: Participants were instructed not to use any substance other than nicotine or caffeine on the day of the study. Recent drinking history was assessed using the 90-day Timeline Followback (TLFB; (Sobell & Sobell, 1992), which assessed drinking days in the past 90 days, as well as total drinks in past 90 days. Problematic alcohol use was assessed by the Alcohol Use Disorder Identification Test (AUDIT; (Saunders, Aasland, Babor, de la Fuente, & Grant, 1993), with higher scores suggestive of more alcohol problems. Participants also completed the following questionnaires:

*Multidimensional Iowa Suggestibility Scale (MISS;* (Kotov, Bellman, & Watson, 2004). This scale assesses susceptibility to influence 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. Higher scores indicate higher overall suggestibility.

*Brief Comprehensive Effects of Alcohol questionnaire (B-CEOA*;(Ham, Stewart, Norton, & Hope, 2005)*.* The B-CEOA 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 & 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 Analyses: Separate linear regressions were conducted to assess relationships among the MISS Total Suggestibility Score, and (1) drinking measures including TLFB (drinks per week, drinks per occasion, drinks per drinking day), and AUDIT scores; (2) alcohol expectancies on the B-CEOA (Liquid Courage, Self-Perception, Sexual Experiences, and Tension Reduction), and (3) drinking motives on the DMQ-R (Social, Coping, Enhancement, and Conformity). Analyses were conducted using SPSS, Version 19.0 (IBM Corporation, NY). Data were checked for normality, and square-root transformed if assumptions for normality were not met. The level of significance for all analyses was set at *p* ≤ 0.05. Resulting p values were corrected for multiple comparisons (for 12 measures: four drinking variables, four B-CEOA measures, and four DMQ-R measures) using a Benjamin-Hochberg correction (Benjamini, 1995).

**Intravenous Alcohol Self-Administration (IV-ASA) study (Study 2).**

Participants: The IV-ASA study was conducted at the Clinical Center of the National Institutes of Health (Bethesda, MD). Data were available from 20 participants, ages 21-45 years of age, recruited from the community. All participants were medically healthy (no current or prior history of any central nervous system, cardiovascular, respiratory, gastrointestinal, hepatic, renal, endocrine, or reproductive disorders; positive hepatitis or HIV test at screening), and had no current DSM-IV psychiatric disorders (including alcohol use disorders), verified by the Structured Clinical Interview for DSM-IV Diagnoses (SCID version 4; (First, 2002). In addition, participants reported drinking five or more drinks on at least one occasion at least once in their lifetime. Before initiation of the alcohol session, participants completed questionnaires including the MISS (Kotov et al., 2004). All participants gave written informed consent to this study, which was approved by the NIH Addictions Institutional Review Board.

Experimental Protocol: The IV-ASA study is described in detail in (Stangl et al., 2017). Participants were required to abstain from alcohol for 48 hours before the study day. On arrival, a breathalyzer test was performed to ensure a zero BAC. A urine sample was collected for a drug screen for all participants and a beta-hCG 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 was then inserted into a vein in the antecubital fossa of (preferably) the nondominant arm using sterile technique. This catheter was used for the alcohol infusion. 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.

The IV-ASA experiment consisted of two phases. During the priming phase (25 min), participants were prompted to push the button to receive four small standardized alcohol infusions resulting in an estimated 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 (‘open bar’) where participants could press a button whenever they chose. The infusion rates were determined using the participants’ age, height, weight and gender in a physiologically based pharmacokinetic model, and implemented using the Computerized Alcohol Infusion System. 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 passed the pre-set upper limit for estimated BAC exposure (100 mg%). An Alcotest 6510 handheld breathalyzer (Draeger Safety Diagnostics, Irving, TX, USA) was administered approximately every 15 min during the session.

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 estimated BAC level fell below 20mg%. The total duration of the session was approximately seven hours.

Subjective measures were obtained serially to assess alcohol effects. These measures were collected at baseline as well as during the directed priming phase (at the 10- and 20-minute time points) and 8 times during the IV-ASA session every 15 minutes, with a final post-infusion measure 15 minutes after the IV-ASA had ended. These measures took roughly 5 minutes to complete. These included the Alcohol Urge Questionnaire (AUQ) (Bohn, Krahn, & Staehler, 1995), which measures a participant’s total urge for alcohol at that moment and the Drug Effects Questionnaire (DEQ) (Fischman & Foltin, 1991) which included five measures of subjective effects of alcohol, including how much participants “feel” the drug effects, “like” the effects, would like “more” of what they received, felt “high”, and felt “intoxicated.” Participants could press for more alcohol during data collection to not interfere with the participant’s opportunity to self-administer alcohol.

Statistical Analysis: IV alcohol self-administration measures were calculated separately for the two phases of the experiment. In the priming phase, we examined subjective response measures from the DEQ of “Feel”, “Like”, “Want”, “High” and “Intoxicated,” and urge for alcohol assessed by the AUQ, at 20 minutes after the priming dose was administered (which is the amount of time expected for individuals to feel peak alcohol effects). Since DEQ ratings are highly dependent on alcohol tolerance (Gilman et al., 2012), all analyses controlled for alcohol drinking history (number of drinks in the past 90 days; TLFB) and for peak BrAC during the priming session.

For the Free-Access phase, we calculated the estimated average BAC (mg%) and the estimated peak BAC (mg%) throughout the first 30 minutes of the session, as the first 30 minutes has been shown to capture the maximum variability in behavior (Stangl et al., 2017), as well at the number of “button presses” to receive alcohol throughout the first 30 minutes of the session. We also calculated peak subjective response measures of “Feel”, “Like”, “Want”, “High” and “Intoxicated” and urge for alcohol assessed by the AUQ. We conducted linear regressions to assess whether the MISS Total Suggestibility Score predicted alcohol self-administration, or subjective responses to alcohol. As in the priming phase, all analyses controlled for alcohol drinking history (number of drinks in the past 90 days; TLFB). Analyses were conducted using SPSS, Version 19.0 (IBM Corporation, NY) and the level of significance for all analyses was set at *p* ≤ 0.05. Resulting p values were corrected for multiple comparisons (for 13 tests: five DEQ variables during priming phase, five DEQ variables during the Free-Access phase, and average BrAC, peak BrAC, and number of button presses) using a Benjamin-Hochberg correction (Benjamini, 1995).

**Results**

**Young Adult Study (Study 1).**

Alcohol Drinking Behavior*:* Greater suggestibility predicted more drinking days in the past 90 days (F = 5.74, p = 0.02), and more drinks in the past 90 days (F = 5.39, p = 0.02), but not average drinks per occasion (F = 0.96, p = 0.33) or AUDIT scores (F = 2.42, p = 0.12). After Benjamin-Hochberg correction (Benjamini, 1995), total drinks in 90 days and total drinking days in 90 days remained significant (Fig 1A).

Alcohol Expectancies (B-CEOA): Greater suggestibility predicted greater alcohol expectancies, including liquid courage (F = 9.58, p < 0.01), altered self-perception (F = 4.84, p = 0.03), and tension reduction (F = = 8.90, p < 0.01) (Fig 1B). These remained significant after correction for multiple testing. Suggestibility did not predict expectancies of sexual experiences (F = 1.79, p = .18).

Alcohol Motives (DMQ): Greater suggestibility predicted each of the four motivational dimensions for alcohol use: social motives (F = 12.0, p < 0.01), coping (F = 13.44, p < 0.01), enhancement (F = 6.48, p = 0.01), and conformity (F = 11.31, p < 0.01) (Fig 1C). These remained significant after correction for multiple testing.

**IV-ASA study (Study 2).**

Priming Phase:Peak BAC achieved across participants during the priming phase was 28.3 mg% (SD = 4.14 mg%). After controlling for alcohol drinking history (number of drinks in the past 90 days), greater suggestibility predicted greater subjective alcohol effects including “Feel” (r2 = 0.26, p = 0.03), “Like” (r2 = 0.21, p = 0.047) “Want” (r2 = 0.24, p = 0.03), “high” (r2 = 0.30, p = 0.02), and “intoxicated” (r2 = 0.26, p = 0.03). All variables except “Like” remained significant after corrections for multiple comparisons.

Free-Access ‘open bar’ Phase*:*  During the first 30 minutes of the free-access phase, the average estimated BAC was 23.7 mg% (SD 9.82 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 = 2.59).

After controlling for drinking history (number of drinking days in the past 90 days), greater suggestibility predicted greater average estimated BAC (r2 = 0.34, p = 0.02), greater peak BAC (r2 = 0.41, p < 0.01), and a greater number of button presses (r2 = 0.43, p < 0.01) (Fig 2A). These variables remained significant after corrections for multiple comparisons. Estimated BAC and button presses for the entire 125-min free-access session were not associated with suggestibility scores (all ps > 0.1), demonstrating that suggestibility predicted alcohol self-administration primarily in the beginning of the free-access session.

After controlling for alcohol drinking history, greater suggestibility predicted greater scores on “Feeling the effects of alcohol” (r2 = 0.47, p = p < 0.01), “Liking the effects of alcohol” (r2 = 0.45, p = p < 0.01), “feeling high” (r2 = 0.50, p = p < 0.01), and “feeling intoxicated” (r2 = 0.56, p = p < 0.01). These variables remained significant after corrections for multiple comparisons. There was not a significant association between suggestibility and “Want more” (r2 = 0.24, p = 0.05).

**Discussion**

These studies together demonstrate that susceptibility to influence is a critical feature associated with alcohol drinking patterns, alcohol motives, and alcohol expectancies in the real world (Study 1), as well as in the laboratory (Study 2). The current studies provide evidence that individuals who are susceptible to influence may drink for two related yet distinct reasons: for external, social reasons; and for rewarding internal states, such as an increased sensitivity to the pharmacological effects of alcohol.

Although there is a large body of literature on the effects of peers on drinking behavior, far fewer studies have used self-reported measures of suggestibility to examine relationships between susceptibility and real-world drinking behavior. Most research has shown that individuals choose peer groups based on the shared norms they value (Crosnoe & McNeely, 2008); in other words, they tend to affiliate with peers whose drinking behavior matches their own. Thus, it is difficult to determine an independent role for social influence susceptibility on hazardous alcohol consumption. Social influence may operate through behavioral modeling, overt encouragement for drinking, covert reinforcement of drinking, and by biasing perceived drinking norms (Borsari & Carey, 2001). In the current study (Study 1), we found significant relationships among individual suggestibility and (1) drinking patterns in the past 90 days, (2) social, coping, enhancement, and conformity-related motives to drink, and (3) liquid courage, altered self-perception, and tension-reduction alcohol expectancies. The relationship between susceptibility to influence and alcohol expectancies is intriguing, as greater positive expectancies for alcohol increases alcohol use and harmful drinking behavior (Bott, Meyer, Rumpf, Hapke, & John, 2005; Leigh & Stacy, 2004; Li & Dingle, 2012). These findings together suggest that greater susceptibility to influence itself may increase risk for the development alcohol use disorders.

In Study 2, suggestibility to influence was associated with the acute reinforcing properties of alcohol, as well as alcohol administration behavior, even after controlling for drinking history. During both the passive “priming” and the active “open bar” phase, more suggestible individuals reported greater effects for “Feel,” “High,” and “Intoxicated.” Furthermore, in the free-access session, participants with higher suggestibility scores self-administered more alcohol. To our knowledge, studies have not assessed how susceptibility to social influence affects subjective alcohol effects, though there is a large literature showing that those who report greater sensitivity to stimulant and rewarding effects of alcohol progress toward more AUD symptoms (e.g. (King et al., 2014)). Previous research has shown that high sensitivity to alcohol’s rewarding effects are associated with heavier drinking and increased risk for alcohol dependence (King et al., 2011; King et al., 2014; Schuckit, 1994), indicating that heightened sensitivity to the stimulant effects of alcohol may be part of an enhancement pathway to drinking. Study 2 demonstrates that individuals who are more sensitive to alcohol may also be more susceptible to social influence, suggesting that social 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.

There are limitations to this study. Both Study 1 and Study 2 are cross-sectional, so we cannot determine whether susceptibility to influence was a causal factor in alcohol use, or whether greater alcohol use could potentially lead to greater susceptibility to influence. In Study 1, 95% of participants also used cannabis, and therefore we might not be able to rule out the influence of cannabis on the relationship between susceptibility to influence and alcohol use. Study 2, with 20 participants, is small, and therefore, we did not have the power to investigate subgroups by age, gender, or other potential moderators, such as impulsivity. Finally, though this is a study of social influence and alcohol administration, all administration procedures occurred while the participants were alone. Future studies could investigate whether groups of participants together amplify the effects observed in this study.

In conclusion, few studies have investigated the relationship between susceptibility to social influence, drinking motives and expectancies, and alcohol consumption and associated subjective effects. We suggest that susceptibility to influence may be an important factor when examining alcohol consumption behavior, and may provide insight into harmful drinking behavior such as binge drinking. Reducing susceptibility to social influence has been a primary component of many adolescent prevention and treatment programs (Larimer & Cronce, 2007), and a recent study suggests that those who are most highly susceptible to peer influence and have heavier-drinking friends receive the most benefit these types of interventions (Hallgren, McCrady, Caudell, Witkiewitz, & Tonigan, 2017). Thus, there is a need for research that examines the link between 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 & Berridge, 1993).

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**Figure Legends**

**Fig 1. (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.Dotted lines represent the 95% confidence interval of the linear regression line.

**Fig 2. (A**) After controlling for drinking history, greater suggestibility predicted greater average estimated 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 DEQ measures, with a trend-level effect for “want more.” Dotted lines represent the 95% confidence interval of the linear regression line.

**Disclosures**

No conflict declared for any authors.

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**Authors Contributions**

Conceived and designed the experiments: BLS, JMG, RMS, VAR. Performed the experiments: BLS, AS, RMS, AD, FM, ERY. Analyzed the data: BLS, JMG. Wrote the paper: JMG, RMS, VAR, AS. All authors have approved the final article.

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