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Linking Trait-Based Influences with Proximal, Contextually Driven Processes to Understand the Relationship Between Alcohol Use and Risk Behavior

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Linking Trait-Based Influences with Proximal, Contextually Driven Processes to Understand the Relationship between Alcohol Use and Risk Behavior

by

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ABSTRACT

Impulsivity-related traits explain a significant and meaningful level of variance in the prediction of drinking behavior. Previous research has demonstrated that although risk taking propensity has been conceptualized as a "trait-like" construct, there are contextual and situational factors that affect an individual's likelihood of engaging in risk taking behavior, including drinking behavior. Despite the well-established relationship between alcohol use and risk behavior (e.g., risky sexual behavior, physical assault, etc.), it is unclear how alcohol-related context influences risk taking on a computerized behavioral task. Grounded in alcohol expectancy theory (which holds that information processing about the rewarding effects of alcohol mediates the influences of different affective processes on drinking-related behavior), the present study—using online-based assessments—examined whether implicitly priming undergraduate social-drinking participants with alcohol-related stimuli (images and arousing expectancy words) would lead to greater risk taking and disinhibition on computerized tasks. Results were complicated by baseline group differences in drinking, expectancies, and the day of the week in which participants completed the task; regardless, the central hypothesis was not supported, as participants exposed to alcohol images and expectancy words were not significantly riskier on the BART or more impulsive on the Go/No-Go than participants exposed to neutral images and words. Exploratory analyses indicated that participants who completed the tasks on days associated with drinking (Thursdays through Saturdays) were significantly riskier than participants who completed the tasks on other days, and that this effect was the strongest when participants were exposed to alcohol primes. While consistent with the context sensitivity of

alcohol cognitions and risk taking, the lack of random assignment to day of the week precludes causal interpretation. Nonetheless, the results indicate that research on the assessment of risk taking in a naturalistic context (e.g., through ecological momentary assessment) is warranted.

INTRODUCTION

Adolescent and young adult alcohol use is characterized by heavy episodic patterns of use. Recent epidemiological data indicate that 38% of full-time college students engaged in at least one episode of binge drinking in the past month (SAMHSA, 2014). Heavy drinking among young adult college students is associated with a range of negative consequences, including unintentional death and injury, sexual abuse, unsafe sex, and academic problems (Hingson, Heeren, Zakocs, Kopstein, & Wechsler, 2002; Hingson, Zha, & Weitzman, 2009; Wechsler et al., 2002).

The magnitude of the individual and social consequences of heavy drinking underscores the importance of identifying its determinants and predictors. Findings from the personality domain have commanded attention as being involved in the etiology of heavy drinking. Specifically, impulsivity, defined as a tendency to "enter into situations, or rapidly respond to cues for potential reward, without much planning or deliberation and without consideration of potential punishment or loss of reward" (Zuckerman, 1994), has a logical theoretical link to heavy drinking; moreover, extensive research has demonstrated a link between self-report measures of impulsivity-like traits and the onset and maintenance of heavy alcohol use. Despite the magnitude of the association, some behavioral scientists have acknowledged the limitations of the self-report modality, particularly as it pertains to impulsive-like traits (e.g., a highly impulsive individual might be reluctant, or unable, to accurately report impulsive tendencies). In response, laboratory-based behavioral tasks have been developed to theoretically capture impulsive behavior, as it occurs naturally. The utility of these tasks is often supported by findings demonstrating their incremental prediction of alcohol-related behavior. Findings from the personality domain indicate that a certain level of risk of heavy alcohol use is conferred by impulsive-like traits.

While impulsivity-related traits explain a significant and meaningful level of variance in the prediction of drinking behavior, this trait-like approach does not account for the more proximal, context-sensitive mechanisms involved in drinking behavior. That is, even highly impulsive individuals may not drink, as there are other influences, both internal and external to the individual, that contribute to the chain of events that precede drinking. To better understand how and why individuals engage in heavy drinking, it is relevant to consider the psychological processes that are directly involved in the decision to drink. Evidence indicates that information processing related to the rewarding effects of alcohol (in the form of alcohol expectancies) mediates the effects of affective systems on drinking-related behavior; thus, investigating how the distal influence of impulsivity-related constructs and the proximal influence of alcohol expectancies interact could provide incremental information about the psychological processes that precede drinking. To this end, the relationship between impulsivity-related traits—as measured by self-report questionnaires and behavioral tasks—and heavy drinking will be reviewed, along with the evidence that implicates alcohol expectancies as a mediator of drinking. Then, the potential for linking these distal and proximal influences will be reviewed. Specifically, examining how exposure to alcohol context (in the form of expectancy-related cues) could affect performance on a laboratory-based task of risk taking propensity (which incorporates elements of reward valuation and impulsivity-related traits) will be discussed.

Impulsivity and Related Traits

Self-reported impulsivity and drinking. Evidence from longitudinal studies suggests that pre-existing impulsivity-related traits are involved in the onset of risky substance use. For example, six to ten year-olds with high levels of novelty seeking traits (as measured by the Tridimensional Personality Questionnaire—TPQ; Cloninger, 1987) were more likely to engage in adolescent substance use than those low in the trait (Masse & Tremblay, 1999). In a sample of college freshmen, high novelty seeking and psychoticism traits (as measured by the TPQ and Eysenck Personality Questionnaire—EPQ; Cloninger, 1987; Eysenck & Eysenck, 1975) predicted alcohol use disorder (AUD) diagnoses seven years later (Sher, Bartholow, & Wood, 2000).

Impulsivity is also elevated in AUD samples relative to controls (Dawe & Loxton, 2004). Further support for the implication of impulsivity in drinking comes from studies that have identified that trajectories of impulsivity and novelty seeking, as measured in the same individuals over time periods including the end of high school and the two years after college, tend to mirror trajectories in drinking (Ashenhurst, Harden, Corbin, & Fromme, 2015). A wealth of evidence indicates that a variety of common behaviors, collectively termed "impulsivity," are associated with risky drinking.

Self-reported impulsivity: A heterogeneous construct. Self-report personality questionnaires are constructed under the assumption that individuals' behaviors are predictable, such that certain behavioral tendencies are manifest across situations. Impulsivity can be understood as a latent construct, representing an amalgam of cognitive and behavioral tendencies. What constitutes "impulsive personality traits" differs according to the items included in test development. Earlier personality theorists developed questionnaires that measured related, but reportedly distinct, factors. Eysenck et al. (1985) utilized factor analysis to develop the Impulsiveness Questionnaire (EIQ), which is composed of an Impulsiveness scale (that measures lack of planning or "acting without thinking") and Venturesomeness scale (that measures thrill seeking). Like the EIQ, the Barratt Impulsiveness Scale (BIS; Patton, Barratt, & Stanford, 1995) includes items that reflect acting without thinking and lack of planning for the future. The BIS distinguished between these components (Motor Impulsiveness and Non-planning Impulsiveness), however, based on factor analysis (Patton et al., 1995). It also includes a third factor, Attentional Impulsiveness, which reflects one's ability to focus or concentrate on tasks. Still, other measures exist that include factors thought to reflect impulsive behavior (e.g., Buss & Plomin, 1975; Cloninger, Przybeck, & Svrakic, 1991; Dickman, 1990; Tellegen, 1982). Although uniqueness and overlap exists among the factors that arise from self-report measures, it is apparent that impulsivity is a heterogeneous construct.

As a result of the range of measures presumably thought to measure the same construct, investigators attempted to identify common factors across several different common impulsivity measures using factor analytic techniques (Whiteside & Lynam, 2001). They proposed that common factors across impulsivity measures (including many of the aforementioned questionnaires) could map onto several aspects of Costa and McCrae's Five Factor Model (Costa & McCrae, 1990). Based on their findings, impulsivity consisted of four broad factors, including urgency (the tendency to act impulsively when in a positive or negative mood), lack of premeditation (acting without thinking of the consequences), lack of perseverance (ability to stay focused on a task), and sensation seeking (the tendency to seek exciting and new experiences) (Whiteside & Lynam, 2001). The differentiation of factors has been useful, in part, because different factors predict unique manifestations of drinking behavior (e.g., sensation seeking has been found to predict frequency in drinking, while urgency predicted problems from drinking; Smith et al., 2007).

Self-report impulsivity: Limitations. Despite the high reliability and predictive validity of self-report measures, researchers have acknowledged the limitations of this assessment modality. Specifically, self-report measures rely on the accuracy of an individual's self-report, which can vary based on a participant's explicit manipulation of responses (e.g., to avoid negative evaluation). The alteration of responses can also occur through implicit effects of context. Responses to a questionnaire require judgment from the individual. This judgment is the end result of the interaction between the present environment (including the items themselves) and the individual's memory. For example, methodological artifacts that are seldom considered may have effects; a study identified that manipulating the order of items in a common sensation seeking measure resulted in different factor structure (Weinberger, Darkes, Del Boca, Greenbaum, & Goldman, 2006). The very act of self-report is a behavior itself, and it introduces variability that might or might not reflect the behavior of interest.

Impulsivity: Laboratory-based tasks. Researchers also have developed laboratory-based tasks intended to model impulsivity. They are often created under the premise that, assuming sufficient experimental control, the actual behavioral manifestation of impulsivity can be modeled in the laboratory; rather than infer behavioral tendencies from an inventory of self-reported behaviors, researchers can observe these tendencies directly. Typically, tasks are created that are devoid of naturalistic cues; if impulsivity were to operate as theorized—that is, stable and trait-like—then a sterile laboratory environment would be the ideal setting for identifying impulsive traits.

As with impulsivity questionnaires, a variety of laboratory tasks have been developed that have proven to be multi-faceted in nature (Cyders & Coskunpinar, 2011). A recent review categorized the various tasks according to the aspect of impulsivity they measure (Cyders & Coskunpinar, 2011). The categories included tasks that measure pre-potent response inhibition (e.g., Go/No-Go task; Marczinski & Fillmore, 2003), ability to resist distraction from task-irrelevant stimuli (e.g., Eriksen Flanker task; Eriksen and Eriksen, 1974), ability to resist proactive interference (e.g., Tolan & Tehan, 1999), delay discounting (e.g., Kirby, Petry, & Bickel, 1999), and distortions of time judgment (e.g., Dougherty, Mathias, Marsh, & Jagar, 2005). Interestingly, a meta-analysis of studies examining the relationships among self-report impulsivity measures and behavioral tasks revealed little overlap across the two modalities (Cyders & Coskunpinar, 2011). Some have suggested that this discreteness is consistent with an interpretation that laboratory tasks are more susceptible to state-based fluctuations than are questionnaires (Cyders & Coskunpinar, 2011, 2012).

Laboratory-based impulsivity tasks and drinking. In contrast to self-report measures, which are consistently identified as significant correlates of real-world alcohol use, laboratory tasks are less consistently related to drinking. For example, the association between pre-potent response inhibition and drinking has been found to vary across studies. Kamarajan et al. (2005) compared pre-potent response inhibition performance between a sample of AUD participants and healthy controls, and identified that AUD participants performed significantly worse. However, other studies have failed to detect differences in response inhibition and drinking status (Courtney et al., 2012; Fernie, Cole, Goudie, & Field, 2010). Delay discounting task findings are also inconsistent. In a sample of college undergraduates, Vuchinich and Simpson (1998) found that heavy social drinkers tended to prefer smaller, more immediate rewards significantly more than lighter drinkers. Other researchers have failed to find a relationship between delay discounting and drinking (e.g., Fernie et al., 2010).

Longitudinal findings are mixed regarding the association between impulsivity task performance and future alcohol-related outcomes. In a large-scale twin study, delay discounting in 14-15 year-olds did not predict future substance use problems at age 17-18 (Isen, Sparks, & Iacono; 2014). In other studies, however, delay discounting, poor response inhibition, and risk taking prospectively predicted alcohol-related involvement in adolescents (Fernie et al., 2013; Nigg et al., 2006).

Personality or trait-based explanations of the role of impulsivity in drinking have incorporated behavioral measures to model putatively discrete tendencies that increase the likelihood of alcohol involvement. Higher levels of alcohol use are then interpreted as a manifestation of a generalized difficulty with inhibiting one's behavior (i.e., response inhibition; Kamarajan et al., 2005). While some evidence suggests an association between response inhibition and levels of alcohol involvement, this conceptualization does not account for reward valuation, which is particularly important when considering impulsive behavior in an alcohol use context (Blakemore & Robbins, 2012). Delay discounting paradigms are useful in accounting for this dimension: an impulsive choice depends, in part, on the value of the reward. Although accounting for reward valuation, delay discounting does not incorporate an element of risk, such that seeking the reward may result in a negative outcome. The "risk" element is conceptually relevant to the understanding of alcohol use as a risky behavior; the degree to which individuals find alcohol rewarding (i.e., their expectations of the effects of alcohol) is positively associated with drinking involvement. In other words, heavy drinking may be considered a behavior in which one seeks greater rewards in spite of the increased likelihood of negative outcomes. This component of risk taking is modeled in the Balloon Analogue Risk Task (BART; Lejuez et al., 2002), which was intended to model risk taking propensity in a laboratory setting.

BART: Risk Taking in the Laboratory

The BART is a computerized behavioral laboratory task in which participants "inflate" an on-screen balloon to earn money (real or hypothetical) or points (toward a larger reward). Each pump results in greater reward. With each inflation, however, the probability of the balloon exploding (and the loss of money earned from that balloon) increases. Thus, the number of pumps is considered a measure of risk taking: as the reward increases, so does the likelihood and magnitude of loss. Risk taking on the BART has been associated with higher levels of self-reported sensation seeking and impulsivity (for review, see Lauriola, Panno, Levin, & Lejuez, 2014). Its utility has been demonstrated in studies linking it to real-world risk-taking behaviors.

BART: External validity. Risk taking on the BART is associated with self-reported occurrence of real-world risky behavior. In a community-based sample of young adults, Lejuez et al. (2002) demonstrated that the BART accounted for unique variance (above self-report risk-related traits) in a summary measure of real-world risk behaviors (including alcohol use, cigarette use, gambling, and other behaviors). These findings were then replicated in a sample of adolescents (Lejuez, Aklin, Zvolensky, & Pedulla, 2003; Lejuez et al., 2007). Similar associations exist between BART risk taking and discrete risk behaviors, including adolescent tobacco and alcohol use. Adolescents who self-reported as having ever smoked a cigarette were riskier on the BART than adolescents who had never smoked (Lejuez, Aklin, Bornovalova, & Moolchan, 2005). Risk taking on the BART has been associated with alcohol use, as well. BART risk taking accounted for significant and unique variance (after controlling for self-reported impulsivity and other factors) in measures of alcohol use and alcohol problem severity among heavy drinking college students (Fernie et al., 2010).

BART: Risk taking and development. Risk taking on the BART may reflect the same tendencies that underlie normative increases in reward sensitivity and real-world risk taking across adolescent development (Spear, 2000; Steinberg, 2008), as evidenced by longitudinal and cross-sectional findings (Collado, MacPherson, Kurdziel, Rosenberg, & Lejuez, 2014; Dougherty et al., 2015; MacPherson, Magidson, Reynolds, Kahler, & Lejuez, 2010). Dougherty et al. (2015) reported increases in the mean number of pumps on the BART over three annual assessments in a sample of 10-12 year-olds with and without a family history of alcohol use disorders (AUDs). Importantly, BART risk taking increased among both groups of participants, regardless of family history status (the relationship between the BART and adolescent drinking was not known, as drinking data was unavailable; Dougherty et al., 2015). Similarly, mean levels of risk taking on the BART increased at each annual follow-up assessment in a three-year study in young adolescents (MacPherson et al., 2010). In addition, increases in BART risk taking and self-reported sensation seeking prospectively predicted increases in alcohol use. Follow-up analyses indicated that level of pubertal development accounted for unique variance in increased risk taking, after controlling for demographic variables (Collado et al., 2014). The BART appears to be sensitive to the changes in real-world risk taking propensity that occur during adolescence.

As BART performance reflects increases in risk taking in adolescence, other developmental stages (as inferred by age) seem to be associated with unique patterns on the task (Ashenhurst, Jentsch, & Ray, 2011; Rolison, Hanoch, & Wood, 2012). In a sample of alcohol dependent adults, age mediated the relationship between the number of AUD symptoms and risk taking on the BART, such that older participants were more conservative (Ashenhurst et al., 2011). Similar associations with age were demonstrated when BART performance was compared across young adults (age $M = 19$) and older adults (age $M = 76$; Rolison et al., 2012). Although total mean levels of risk taking were similar across groups, statistical modeling of the data revealed that the younger participants tended to be riskier than the older participants in the earlier trials. After the early trials, the older adults' risk taking increased to the levels of the younger participants. The authors contended that while older adults seemed to make riskier choices only after gaining experience with the task, the younger adults were risky without any prior learning (Rolison et al., 2012). This finding is consistent with recent theories of adolescent development, in which increases in novelty seeking and risk taking serve an adaptive role alongside increases in independence (Spear, 2000).

BART: Contextual effects. In addition to fluctuations in risk taking over time, an individual's likelihood of engaging in risky behavior may be influenced by immediate contextual factors (both internal and external to the individual). Additional experimental evidence has indicated that stress and fatigue influence BART performance (Acheson, Richards, & de Wit, 2007; Lighthall, Mather, & Gorlick, 2009). Following a stress induction, risk taking increased among males and decreased among females (Lighthall et al., 2009). In another sample of healthy volunteers, experimentally induced sleep deprivation led to reduced risk taking among female, but not male, participants (Acheson et al., 2007).

Aspects of social context, which are often associated with engagement in real-world risky behaviors (e.g., heavy drinking among college students), affect BART performance. Given the close link between risk taking and social/peer influence in adolescence, investigators tested the effect of a peer component on the BART in a sample of older adolescent smokers and non-smokers (Cavalca et al., 2013). The presence of a peer (who provided "strategies on when to pump") increased risk taking among smokers (Cavalca et al., 2013). Risk taking, as it occurs in mating contexts, has also been examined in the laboratory using the BART. Baker and Maner (2009) examined BART performance following a cue in which males were told their BART performance would be viewed by a romantically available female confederate. Their findings demonstrated that, among those males who completed the BART in front of the romantically available female, BART risk taking was positively associated with self-reported sexual arousal; this association was not present in conditions involving a romantically "unavailable" female confederate (or no audience). This pattern is consistent with an evolutionary perspective of risk taking among males, such that risk taking behaviors can serve as "mating signals" to attract potential mates (Baker & Maner, 2009). It also highlights the situation-dependent nature of risk taking behavior.

Considering the sensitivity of risk taking to contextual factors, measuring BART performance in alcohol-related contexts could be useful. Corbin et al. (2015) measured the effects of alcohol or placebo administration on BART performance in laboratory or simulated bar contexts, hypothesizing that the highest levels of risk taking would be observed among those drinking alcohol in the simulated bar. Contrary to the authors' expectations, no main effects were observed; BART performance did not differ across the conditions. The authors suggested that strong placebo responses attenuated the BART effects. It is possible that placebo alcohol could have elicited behavior consistent with one's alcohol expectancies. However, because alcohol cues were present in each condition, they were unable to test this hypothesis (Corbin et al., 2015). Other studies of the effects of acute alcohol intoxication on BART performance were similarly designed, with alcohol cues present in each condition (Euser, van Meel, Snelleman, &

Franken, 2011; Peacock, Bruno, Martin, & Carr, 2013; van Ravenzwaaij, van der Maas, &Wagenmakers, 2011). Effects of alcohol administration on risk taking were evident in one sample, in which these participants who received alcohol were riskier over the first 10 BART trials than participants who received placebo (Euser et al., 2011); other studies found no differences between alcohol and placebo groups (Peacock et al., 2013; van Ravenzwaaij et al., 2011). The contributing role of alcohol-related context on the BART remains unclear.

The BART is a face valid task that has been demonstrated to effectively measure risk taking propensity in a laboratory setting. Unique from other behavioral measures of impulsive-like tendencies, it incorporates aspects of reward valuation in the context of the potential for loss—a concept with obvious parallels to heavy alcohol use. Recent research indicates that risk taking propensity is responsive to context, including affective and physiological states (Acheson et al., 2007; Lighthall et al., 2009) and aspects of the social setting (Baker & Maner, 2009; Cavalca et al., 2013). To date, however, it is unclear how alcohol-related context is associated with risk taking on the BART; existing research has been directed toward identifying the acute effects of alcohol on risk taking, with mixed results (Euser et al., 2011; Peacock et al., 2013; van Ravenzwaaij et al., 2011). Integrating into the BART other known mechanisms that underlie the relationship between alcohol and its effects on behavior could help to explicate this association. Extensive literature supports that individuals' expectations about the rewarding effects of alcohol are antecedents of drinking-related behavior (including both the decision to drink, and one's behavior while drinking; Goldman, Darkes, Reich, & Brandon, 2010). Incorporating alcohol expectancy paradigms into the BART could provide insight on the relationship between alcohol use and risky behavior.

Alcohol Expectancies

Alcohol expectancy theory states that one's experiences with, and one's learning of, the effects of alcohol guide drinking-related behavior (Goldman, 2002). These associations between behavior (drinking) and outcome (rewarding effects) are theorized to exist in memory as "templates." Upon encountering future relevant stimuli, memories (information) about behaviors that facilitate obtaining that reward are thought to be the basis for determining output (Wulf & Prinz, 2001). Expectancies may be considered an anticipatory processing system that mediates pathways involving emotion, motivation, cognition, and perception (Reich & Goldman, 2015).

Expectancy questionnaires and drinking. The link between alcohol expectancies and drinking was initially established following the development of psychometrically valid questionnaires that assessed individuals' alcohol expectancies (e.g., Brown, Goldman, Inn, & Anderson, 1980). This research emerged, in part, from studies of alcohol placebo effects, which implicated cognition as a determinant of alcohol-related behaviors (e.g., Rohsenow & Marlatt, 1981). Brown et al. (1980) created the Alcohol Expectancy Questionnaire (AEQ), a single measure that encompassed a wide range of alcohol expectancies. As individuals' expectancies would presumably vary based (at least partly) on their direct experiences with alcohol, the authors accurately predicted that expectancies could be related to consumption patterns (Brown et al., 1980). In a community sample of adults, heavier drinkers tended to have higher expectancies of aggression and sexual enhancement, while lighter drinkers generally had expectancies about the positive effects of alcohol (Brown et al., 1980). Other expectancy questionnaires have been used to demonstrate the relationships among drinking and individuals' expected affective, behavioral, cognitive, and sensory effects of alcohol (Goldman & Darkes, 2004). In a sample of college undergraduates, endorsement of positive and arousing expectancies accounted for unique variance in drinking measured one year later (Goldman &

Darkes, 2004).

Expectancy operation. While expectancies have been shown to uniquely predict drinking patterns, experimental studies have demonstrated the cognitive operation of expectancies, and their influence on subsequent drinking. Specifically, context, in the form of semantic, visual, or environmental cues, activates expectancies (i.e., the "templates" that guide cognition and behavior based on relationships between actions and expected outcomes). These contexts lead to measurable influences on cognition and behavior.

Studies have used implicit priming to demonstrate alcohol expectancy operation (Reich et al., 2010). Implicit priming has been utilized, as it is thought to mimic cognitive processes as they occur in natural contexts, in which stimuli influence cognitions outside of conscious awareness. To test this, Reich et al. (2005) presented two groups of participants with a word list consisting of grocery items and alcohol expectancy words. By presenting one group with a list beginning with the word "milk," and the second group with a list beginning with the word "beer," the authors predicted that recall of the lists would be dependent on the semantic set activated. Indeed, participants in the "milk" condition recalled significantly more grocery items than alcohol expectancy words (Reich et al., 2005). Participants in the "beer" condition, particularly those with heavy drinking histories (and, hence, a presumably larger and more strongly associated memory network of expectancies), recalled more alcohol expectancy words than grocery words.

Evidence indicates that alcohol cognitions vary according to the immediate environmental setting. Wall and colleagues (2000) compared expectancy endorsement (on a questionnaire) in college students exposed to either a naturalistic bar setting or a standard laboratory setting; participants in the bar setting reported significantly higher expectancies than those in the laboratory. Undergraduates with heavy, light, and no drinking histories studied word lists of alcohol expectancy words (Reich, Goldman, & Noll, 2004). The implicit effect of context was tested by comparing false memory for expectancy words in a laboratory bar context and a neutral context. The findings indicated that, among heavy drinkers, more false alcohol expectancy words were recalled in the bar context than in the neutral context (Reich et al., 2004). Among lighter drinkers, the number of falsely recalled expectancy words did not differ between contexts. As noted by the authors, these findings are consistent with alcohol expectancy theory, in which context (in this instance, environmental) activates context-specific templates in memory to guide cognition.

Evidence of expectancy manipulation and its effects on ad libitum drinking. Activation of alcohol expectancy concepts through implicit priming has been shown to influence amount of drinking in laboratory settings (e.g., Carter, McNair, Corbin, & Black, 1998; Roehrich & Goldman, 1995; Stein et al., 2000). To validate the effects of increased drinking as due to expectancy processes (rather than affective responses), the amount of drinking following an expectancy prime was compared to the amount of drinking following an affective prime (Stein et al., 2000). Participants who were presented with positive expectancy words drank significantly more than those who were presented with either neutral expectancy words or positive-mood-inducing music (Stein et al., 2000). While affect contributes to drinking behavior, these findings indicate that, in a laboratory bar setting, anticipatory processes influence drinking behavior.

Effects of expectancy priming on non-consumptive behavior. Consistent with expectancy theory, the effects of priming with alcohol-related stimuli are observable on non-consumptive behavior. Friedman et al. (2005) measured the effect of implicit semantic alcohol primes on males' judgments of female attractiveness. Participants primed with alcohol words rated women as more attractive than participants primed with non-alcohol words. Consistent with the context-sensitive nature of expectancies, participants' pre-existing expectancies of alcohol as a sexual facilitator predicted the attractiveness ratings, but only following the alcohol prime (Friedman et al., 2005). Tan and Goldman (2015) demonstrated preliminary evidence of the involvement of sexual alcohol expectancies in mating behavior. Following implicit exposure to pheromones from a fertile (i.e., ovulating) female, male participants drank more placebo alcohol and exhibited more sexual approach behavior than those exposed to a non-fertile female. Importantly, a correlation between participants' expectancies of alcohol as a sexual facilitator and drinking amount was observed only in the fertile condition; although the study design precluded a test of expectancies as a mediator, the results demonstrate a relationship between sexual expectancies, drinking, and subsequent mating behavior (Tan & Goldman, 2015). Freeman and colleagues (2010) exposed participants to alcohol or neutral images, and found that participants who viewed the alcohol images exhibited more social disinhibition than those who viewed neutral images. Additional evidence exists for the effects of alcohol-related cues on aggression (Friedman, McCarthy, Bartholow, & Hicks, 2007), social group bonding (Moltisanti, Below, Brandon, & Goldman, 2013), and physical balance (Cox, Van Enkevort, Hicks, Kahn-Weintraub, & Morin, 2014). Together, these findings suggest that expectancies are fundamental and automatic anticipatory processes that direct behavioral output.

Alcohol expectancies, risk taking, and response inhibition. Given the associations among alcohol expectancies, exposure to alcohol-related cues, and non-consumptive alcohol-related behaviors, the relationship between expectancies and risk taking in the presence of alcohol-related cues is of interest. One previous study (described earlier; Corbin et al., 2015) measured participants' subjective responses to alcohol or placebo prior to completing the BART, and failed to find interactions between level of response to alcohol and mean number of pumps on the BART. However, because alcohol cues were present in each condition (and potentially activating expectancies), determining whether alcohol-related primes affected risk taking was unclear. Similarly, studies that investigate the effects of alcohol on the Cued Go/No-Go task often are not designed to capture expectancy effects (e.g., Marczinski et al., 2012).

Recent conceptualizations of the role of alcohol in the social agency of late adolescents consider alcohol as the "perfect chemical facilitator" of risk taking and socializing (Reich & Goldman, 2012). That is, the expected effects of alcohol enable (or make more likely to happen) risky behaviors that would otherwise be inappropriate. For instance, the commonly reported expectancy of reduced inhibitions could make sexual encounters more likely to occur (Reich & Goldman, 2012). Given how expectancies mediate the influence of emotion, motivation, and other systems on alcohol-related cognition and behavior (see Reich & Goldman, 2015), it is relevant to consider how alcohol expectancies would relate to risk taking as measured by the BART, which captures unique variance in real-world risk taking.

Present Study

The present study examined the effect of implicit priming of alcohol-related pictures and alcohol expectancy words on risk taking on the BART; it also examined the effect of these primes on response inhibition, as measured by the Go/No-Go task. It was hypothesized that priming participants with alcohol-related stimuli (images and positive and arousing expectancy words) would lead to greater risk taking and impulsivity compared to priming participants with neutral, non-alcohol stimuli (images and words). Moreover, previous research using similar alcohol-related implicit priming paradigms has shown this method to be effective at inducing behavior consistent with expectancy activation (e.g., Roehrich & Goldman, 1995). Because of the proposed theoretical link between expectancy activation and subsequent risk taking and impulsive behavior, it was predicted that risk taking and impulsivity levels would vary based on the levels of contextual information (i.e., risk taking and impulsivity would be greatest when alcohol expectancy words are primed with alcohol images, while risk taking and impulsivity would be lower following neutral words paired with alcohol images; when expectancy words were primed with neutral images, risk taking and impulsivity would be lower, while the least amount of risk taking and impulsivity would be in the combined neutral word and neutral image condition). The decision to include alcohol-related images was intended to provide additional context for the expectancy outcome words, which could become more relevant (and more likely to influence non-consumptive alcohol-related behavior—i.e., risk taking and impulsivity) than if presented independently. Secondly, the combination of the two variables in a factorial design allowed for the determination of the relative influence of the stimuli modality (i.e., images versus words) on task performance. To determine whether implicit priming could also affect impulsivity (response inhibition, in particular)—a related, but distinct, putatively trait-like risk factor for alcohol use—participants completed the Cued Go-No/Go task following the BART.

METHOD

Design

This investigation was presented to participants as a study about the effects of different types of behavioral tasks on memory. The actual aim of the study was to examine the effect of implicit visual and verbal alcohol expectancy primes on measures of risk taking (BART performance) and impulsivity (the Go/No-Go task). Undergraduate students were randomly assigned to one of four experimental priming conditions in a 2 x 2 design (Figure 1; alcohol-related images and alcohol expectancy words, alcohol-related images and neutral words, neutral images and alcohol expectancy words, or neutral images and neutral words). To reduce the likelihood of demand effects, the stimuli were chosen and the procedure designed so as to present alcohol cues in a surreptitious manner. To present the alcohol images unobtrusively, the alcohol-related images consisted of a series of still images from a television series that takes place in a bar; the non-alcohol/neutral images consisted of still images from a television series that takes place in a restaurant devoid of alcohol cues. The alcohol expectancy and neutral words were embedded in a separate distractor task. After viewing the respective primes, participants completed the BART. Participants completed the Go/No-Go task after the BART. The crossed design allowed for measuring the independent effects of each type of prime on risk taking. This is theoretically relevant, as greater risk taking following the combined alcohol image and expectancy primes would provide further evidence for a semantic-memory-based process; when expectancy words are presented without a prior alcohol context, they may be less likely to activate alcohol-specific memories (which are theorized to influence drinking-related behavior).

Participants also answered a single free association question about the expected effects of alcohol ("Alcohol makes me _____"). The specific instructions were adapted from those used in other studies (see Reich, Below, & Goldman, 2010). This item was intended to serve as a manipulation check; prior studies have demonstrated that free associate responses are sensitive to contextual variation, and that they indicate that alcohol expectancy cognitive networks were activated (e.g., Krank, Wall, Stewart, Wiers, & Goldman, 2005).

Participants

One-hundred and forty-one undergraduate students enrolled in psychology courses at the University of South Florida were recruited through SONA, an online research participant database. Given that alcohol expectancies are linked with social context and the increased occurrence of risky behavior in college-aged individuals, students between 18 and 25 years old were recruited. Participants were required to be English speaking, and to also consume alcohol at least 7-10 times per year, and at least once during the 30 days prior to participating in the study. Participants were randomly assigned to one of four conditions (mentioned above). Group assignment was determined through the random assignment feature of the online-based Inquisit Millisecond software system (Inquisit 5.0, Millisecond Software, Seattle, WA).

Measures

Drinking Questionnaire. Data on participants' drinking patterns were gathered with a brief questionnaire. The measure includes items on self-identified drinker "class" (possible responses range from 0 = *abstain from alcohol*, to 7 = *recovering alcoholic*), frequency of drinking during the past year (possible responses range from 0 = *never*, to 8 = *5 or more times* *per week*), type of drink typically consumed (items include *beer*, *wine*, *hard liquor*, and *I don't know*), quantity per drinking occasion (possible responses range from 0 = *none; I don't drink*, to 9 = *17 or more drinks*), and frequency of intoxication during the past year (possible responses range from 0 = *never; I don't drink*, to 8 = *5 or more times per week*).

Alcohol Use Disorders Identification Test (AUDIT; Babor, Higgins-Biddle, Saunders, & Monteiro, 2001). The AUDIT is a 10-item self-report questionnaire intended for use as a brief screening measure to identify hazardous and harmful levels of alcohol use. Response options range from 0 to 4, with higher values reflecting a greater frequency of problems due to alcohol use. The AUDIT has demonstrated good internal reliability (Cronbach's alphas > .80) in other samples of college students (Kokotailo et al., 2004).

Alcohol Expectancy Multiaxial Assessment (AEMax; Goldman & Darkes, 2004). The AEMax is a 24-item self-report questionnaire that measures the frequency with which individuals anticipate certain effects of alcohol (i.e., "Drinking alcohol makes one_____."). Responses are based on a 7-point Likert-type scale (0 = Never, 6 = Always). The measure includes items along a continuum of valence (positive and negative) and arousal (arousing and sedating). The measure generates 8 expectancy subscales that represent the full range of expectancy dimensions (Social, Horny, Attractive, Egotistical, Dangerous, Sick, Sleepy, Woozy). The AEMax prospectively accounts for significant variance in college student drinking (34% in the initial validation sample; Goldman & Darkes, 2004). For the present study, participants' mean item responses to the positive, positive/arousing, and arousing factors (i.e., Social, Horny, Attractive) were used for all analyses.

Negative and Positive Urgency, Premeditation, Perseverance, and Sensation Seeking—Short Version (SUPPS-P; Cyders, Littlefield, Coffey, & Karyadi, 2014). The

SUPPS-P is a 20-item self-report questionnaire that assesses aspects of impulsivity. The subscales include negative urgency ("Sometimes when I feel bad, I can't seem to stop what I am doing even though it is making me feel worse."), positive urgency ("I tend to lose control when I am in a great mood."), (lack of) premeditation ("My thinking is usually careful and purposeful."), (lack of) perseverance ("Unfinished tasks really bother me."), and sensation seeking ("I quite enjoy taking risks."). Items are scored on a 4-point Likert scale (*agree strongly* = 1; *disagree strongly* = 4). Internal reliability estimates range from .74 to .85 (Cyders et al., 2014). As aspects of impulsivity have been positively associated with riskiness on the BART and Go/No-Go response inhibition in previous studies (e.g., Cyders & Coskunpinar, 2011; Lauriola et al., 2013; Lejuez et al., 2002), they are important variables to consider when determining the relative influence of different variables on task performance. Mean item responses within each scale were used for the present study.

Balloon Analogue Risk Task (BART; Lejuez et al., 2002). The BART is a computerized task in which a participant earns money or points by "inflating" a balloon on a computer screen. In the present study, participants earned 25 points with each pump. These points are deposited in a temporary "bank" (in which the amount is not revealed to the participant). Following each pump, the participants have the option to inflate the balloon further, but they risk losing all of the points earned on a given balloon if the balloon explodes. The participants are not made aware of specific explosion points; rather, they are told that the balloons can explode at any point—from the first pump, up until the balloon fills the entire screen. The participants may also choose to press a button labeled "Press to Collect $$$," in which the amount from the temporary bank is deposited into the permanent bank. Points in the permanent bank are not affected by subsequent balloon explosions. The amount in the permanent bank is displayed beside the balloon, in a box labeled "Total Earned." This amount is updated immediately after the collect button is pressed. A new trial (balloon) appears immediately following either a balloon explosion or collection of points.

The BART contains the following on-screen instructions, which are presented immediately before beginning the task.

> Now you're going to see 30 balloons, one after another, on the screen. For each balloon, you will use the mouse to click on the box that will pump up the balloon. Each click on the mouse pumps the balloon up a little more.
>
> BUT remember, balloons pop if you pump them up too much. It is up to you to decide how much to pump up the balloon. Some of these balloons might pop after just one pump. Others might not pop until they fill the whole screen.
>
> You get points for every pump. Each pump earns 25 points. But if a balloon pops, you lose the points you earned on that balloon. To keep the points from a balloon, stop pumping before it pops and click on the box labeled "Collect."
>
> After each time you collect or pop a balloon, a new balloon will appear.
>
> You make 25 points for each pump. You save the points from a balloon when you click "collect." You lose points from a balloon when it pops. There are 30 balloons.

The explosion points are determined prior to each session by random number generation. Specifically, the program generates a random list of 30 numbers, from 1-128, until it arrives on a list with an average value of 64 (Lejuez et al., 2002). This method of determining explosion points is frequently used by other studies (e.g., Bornovalova et al., 2009; Fernie et al., 2010; Lejuez et al., 2002). A total of 30 trials were run for each participant (Bornovalova et al., 2009; Cyders et al., 2010; Fernie et al., 2010; Lejuez et al., 2002).

The BART produces multiple outcome variables, including the adjusted mean number of pumps (AMP), total number of explosions, and total points earned. The most commonly utilized outcome variable is the AMP. The AMP is computed by averaging the number of pumps on balloons that do not result in explosions. This average is typically preferred to an absolute mean number of pumps, as it avoids restricting variability across participants. For the present study, only the AMP will be used in the primary analyses.

Cued Go/No-Go Task. The Go/No-Go Task is a computerized task that assesses inhibitory control. Participants are instructed to press a key as quickly as possible when presented with the target shape—a green rectangle ("Go" signal)—and to refrain from pressing the key when presented with the "No-Go" target—a blue rectangle. Immediately preceding each trial is a cue that indicates which signal is likely to follow. As with the study that first implemented this task (Fillmore et al., 2006), a vertical rectangle preceded the "Go" signal on 80% of the trials, and it preceded the "No-Go" target on 20% of the trials. Similarly, a horizontal rectangle preceded the "No-Go" target 80% of the time, and it preceded the "Go" target 20% of the time. Thus, the vertical rectangle cue facilitates an anticipatory response to the "Go" target, and requires greater inhibitory control from the participant when it precedes the "No-Go" target. The task continues for 250 trials, which allows for balancing the vertical and horizontal cue conditions with 5 different stimulus onset asynchrony times (Fillmore et al., 2006). The error rate for trials in which the cue was "Go" and target was "No-Go" was the primary outcome for this task.

Visual primes. The participants were presented with a series of images according to their experimental condition. In order to reduce the potential for demand effects that could result from presenting images of alcoholic beverages in isolation, the present study included images in which alcohol is one feature of a larger context. The alcohol images included 20 still images from scenes from episodes of the television show *Cheers* (which involves a bar setting, with alcohol present). The neutral images included 20 still images from scenes from the television show *Newhart* (which involves a restaurant inside a Vermont inn, with no alcohol present). Images from these shows, which are both unlikely to have been preferred shows of the targeted age group in the present sample, will reduce the likelihood of differential attention paid to the alcohol versus neutral primes based on third variables (e.g., gender). In addition, they depict relatively similar scenes, in which a group of middle-aged adults are filmed in a larger context of a restaurant setting. Participants were instructed to pay attention to the images, as questions will be asked about them. Each image was presented for 5 seconds at a time.

Verbal primes. The verbal primes were presented with words according to their experimental condition. In the present study, words were presented in a modified Stroop paradigm (Stroop, 1935), in which participants are required to indicate the color of a word (by pressing a certain key on a computer keyboard). This response modality (pressing a key, rather than saying the word out loud, as is frequently done in Stroop paradigms) has been shown to elicit greater interference in heavy, as compared to light, drinkers (e.g., Rofey, Corcoran, & Kavanagh, 2006); moreover, similar stimuli exposure (i.e., briefly presented text) and participant response (i.e., keyboard button press) paradigms have effectively primed non-consumptive alcohol-related behavior in other studies (e.g., Friedman et al., 2007; Moltisanti et al., 2013). In the present study, a fixation cross was presented for 500 ms, followed by the target word, which remained on the screen for a maximum of 2000 ms. In the alcohol word condition, words included positive and positive/arousing alcohol expectancy outcomes, which have previously been identified as associated with drinking (Rather et al., 1992). They were chosen, as they are likely (particularly when combined with alcohol context) to activate alcohol-related concepts in memory (e.g., Stein et al., 2000). Words in the alcohol condition included *funny, confident, jolly, sociable, noisy, courageous, emotional, brave, outgoing,* and *talkative*. Words in the neutral word condition included adjectives that match the positive expectancy words in terms of length, difficulty, and frequency of use (Nelson, McEvoy, & Schreiber, 2004; Stein et al., 2000). Words in the neutral condition included *heavy, enormous, wide, distant, soft, difficult, tough, abundant, dense,* and *elongated*. Words in each condition were presented in random order, a total of five times (for a total of 50 trials per participant).

Participants were instructed in the following manner:

> In the following trials, you will be seeing words presented in different colors. Your task is to indicate what color the word is. Indicate the color of the word by pressing either of the following: 'd' for red; 'f' for green; 'j' for blue; 'k' for yellow.
>
> You want to name the color as quickly as possible, but you also want your answer to be correct.

Free Associates Task. Participants also answered a single free association question about the expected effects of alcohol ("Alcohol makes me _____"). The specific instructions were adapted from those used in other studies (Reich & Goldman, 2005):

> In the blank spaces below, please enter the words or short phrases you would use to complete the phrase "Alcohol makes me _____." Please enter your responses in order, starting with the top blank and working down toward the bottom or last (fifth) blank. Please type whatever first comes to mind. Do not think too long.

This item was intended to serve as a manipulation check; prior studies have demonstrated that free associate responses are sensitive to contextual variation, and that they indicate that alcohol expectancy cognitive networks were activated (e.g., Krank, Wall, Stewart, Wiers, & Goldman, 2005). Responses were coded according to their valence (positive, neutral, or negative), as determined by the norms reported in Reich and Goldman (2005).

Recency of last drinking episode. Participants were asked a single question about the how recently they last drank alcohol, with response options including "More than 30 days ago," "Within the last 30 days, but more than a week ago," "Within the last 7 days, but more than a day ago," "Within the last 24 hours," and "Currently drinking." Given that participants were completing the protocol remotely, it is conceivable that they could be actively drinking alcohol while completing the task; the manipulations in this study were based on the presence or absence of alcohol cues, so eliminating the most obvious cues (i.e., alcoholic drinks) was important. By including a scale of other response options, potential moderators of priming effects could be explored.

Procedure

Overview. Participants registered to participate in the study through SONA. Collection of the DQ, AUDIT, AEMax, and SUPPS-P took place online, prior to completion of the study protocol; importantly, these measures were collected as part of mass testing procedures, which were not tied to this specific study. By keeping the alcohol-related self-report measures separate from the study, the likelihood of demand biases was reduced.

Participants completed the study protocol online.

Specifics. Participants arrived at a page that includes the informed consent. To reduce demand characteristics that could arise from participants being aware of the link between alcohol images or expectancy words and risk taking, participants were informed that the study is an attempt to better understand how memory (i.e., the visual primes) and reaction time (i.e., the

Stroop) might be related to the decisions and actions people make (i.e., the BART and Go/No-Go). In addition to the informed consent, the landing page also included a link to download the plugin necessary to run the study. This link automatically initiated the study protocol. Participants were randomly assigned to one of four conditions by the experimental software.

Following the informed consent, participants were presented with the instructions for the visual primes; as described earlier, the participants were instructed to pay attention to specific features of the scene, as questions would be asked following a distractor task. Following the visual primes, the Stroop instructions and task were initiated. Then, participants completed the BART. Participants completed the Go/No-Go task (which takes approximately 5 minutes) after this. Next, they completed the Free Associates task, followed by brief demographics questions, including the question about the amount of time since last drink.

Analyses

Outliers, group equivalency, and normality. Data from all of the drinking, expectancy, personality, and dependent variables (i.e., BART and Go/No-Go) were examined for outliers. After visually identifying outliers using boxplots, their impact on the group mean was determined by comparing a 5% trimmed mean with the original group mean; similar values would suggest that these responses did not significantly affect the group mean. Outliers that were greater than 2 interquartile range units from the mean were Winsorized (i.e., by replacing the extreme data point with a value one unit above the next highest in the distribution; Tabachnick & Fidell, 2007). Go/No-Go task data were excluded if the primary outcome measure—inhibition failures on "go" cues—was greater than 3 SDs from the mean. Extreme error rates (e.g., incorrectly responding to 80% of trials) in the present sample are likely to reflect poor attention to the task or misunderstanding of the instructions. After addressing outliers, the distributions of the drinking, expectancy, and personality measures were assessed for normality. Distributions were considered non-normal if their skewness statistic exceeded ± 2 (Tabachnick & Fidell, 2007); log transformations were then computed.

Prior to drawing any conclusions regarding the effect of priming condition, it was necessary to examine the make-up of the groups to ensure no pre-existing group differences existed on variables potentially related to BART performance. Thus, the four groups' baseline data were compared. Specifically, separate ANOVAs were run to compare the four groups' DQ items, AUDIT scores, AEMax positive factor scores, and SUPPS-P scores. Additionally, an ANOVA was run to compare the mean ages of the groups. Variables that differed between groups were statistically controlled for in the main analysis.

Effect of primes on risk taking and response inhibition. To determine whether the levels of risk taking or response inhibition increase according to amount of alcohol context in the priming conditions, separate (for the BART and Go/No-Go) one-way ANOVAs with planned polynomial (linear) contrasts were run. It was predicted that the level of risk taking and impulsivity would increase accordingly, such that the lowest levels would be observed in the neutral image conditions. That is, compared to the combined alcohol image and expectancy word prime condition, risk taking and impulsivity levels would decrease in a stepwise fashion; risk taking would be lower following neutral words paired with alcohol images; when expectancy words were primed with neutral images, risk taking and impulsivity would be lower, while the lowest levels of risk taking would be in the combined neutral word and neutral image condition.

To determine whether there were differential effects on risk taking or impulsivity according to the type of prime, separate 2 (image prime) x 2 (verbal prime) ANOVAs (with

AMP and inhibition failures on "Go" cue trials as the DV) were computed. Significant main effects of image prime and verbal prime were predicted. Planned comparisons were computed, comparing the combined alcohol visual prime and alcohol expectancy prime condition against the other three conditions (while accounting for the possibility of type one error by using a Holm-Bonferroni corrected alpha level). It was predicted that further follow-up analyses would indicate that risk taking levels would vary based on the levels of contextual information.

Influence of preexisting expectancies on the effect of alcohol prime on risk taking. To investigate the possibility that the combined alcohol image and expectancy priming condition affected risk taking or response inhibition among a subset of participants with high preexisting expectancies, participants' mean responses to the AEMax subscale items representing the positive, positive/arousing, and arousing factors (i.e., social, horny, and attractive scales) were entered as predictors (along with alcohol priming condition—combined alcohol images and expectancy words versus neutral images and neutral expectancy words—and the condition-by-positive AEMax score interaction) in a multiple regression analysis, with AMP as the DV. A significant condition-by-AEMax score interaction was predicted, such that the effect of the combined alcohol prime on risk taking would be particularly strong among participants with higher positive/positive arousing/arousing expectancies.

Relationship between self-report measures of impulsivity and behavioral measures of risk taking and impulsivity. Correlations within each group's data were also examined. As impulsivity and sensation seeking are considered underlying traits that contribute to risk taking, the SUPPS-P urgency and sensation seeking subscales were expected to be positively related to BART performance. Specifically, the sensation seeking and (positive and negative) urgency subscales were expected to be related to AMP (regardless of experimental condition), based on prior research. On the Go/No-Go task, "Go" cue inhibition errors were predicted to be positively associated with the lack of premeditation and lack of perseverance scales, per prior research (Cyders & Coskunpinar, 2011).

Effect of primes on free association task. To determine whether the primes activated expectancy networks, the proportion of valence ratings of the first free associate (i.e., positive, neutral, or negative) were compared across experimental conditions using a chi square analysis. We expected that a higher proportion of positive valence ratings would be endorsed in conditions with either alcohol images or expectancy words compared to the condition in which participants were exposed to neutral images and neutral words.

Relationship between drinking and behavioral measures of risk taking and impulsivity. The relationship between drinking and BART performance has not always been consistent across studies, despite the obvious theoretical relationship between the two. We expected to find a positive relationship between the drinking variables and AMP, regardless of experimental condition. Similarly, we predicted a positive association between "Go" cue inhibition errors and drinking measures.

RESULTS

Data Auditing

Prior to examining background (i.e., demographic, personality, and drinking) data of the experimental groups, data from the Stroop and BART were inspected to remove participants who were not attending to the tasks (see Figure 2). For the Stroop task, lack of engagement was inferred when a participant's total number of correct responses to the word color was 2 standard deviations below the sample mean ($n = 4$; the majority of these participants did not enter a response for any of the Stroop items). Lack of engagement in the BART was inferred when participants did not pump at least one time over the last 10 balloons, which suggested that participants were "clicking through the task." This resulted in 8 participants being excluded from further analyses.

Premorbid Group Characteristics

Personality and drinking data were examined for outliers (separately, by group) prior to comparing the group means. Outliers were identified in the SUPPS-P negative urgency, lack of premeditation, sensation seeking, and positive urgency scales. Closer inspection of each subscale indicated minimal differences between the 95% trimmed means and group means, suggesting that the outliers had minimal impact on the group mean; in addition, all of the outliers were within 2 interquartile range units, and the distributions of the groups did not appear to violate assumptions of normality (i.e., with a skewness statistic less than 2). These values were retained. Examination of the AEMax positive factor boxplots revealed several positive and negative outliers in the neutral image/expectancy words condition and 2 negative outliers in the alcohol image/expectancy words conditions; these values were > 2 interquartile range units from the mean, and were therefore Winsorized. The distributions were approximately normal. Among the drinking variables, outliers were identified in each group's AUDIT total score data (1 value in the neutral image/neutral word, 1 value in the neutral image/expectancy word, 3 values in the alcohol image/neutral word, and 2 values in the alcohol image/expectancy word conditions); these values were Winsorized. The resulting distributions of AUDIT total scores were within the limits of normality.

In order to test the main hypotheses, it was necessary to first determine whether the experimental groups differed in terms of relevant background characteristics, including demographic, personality, and drinking measures. Descriptive data of demographic and personality measures are included in Table 1. Groups did not significantly differ in terms of gender, ethnicity, or age (*p*s > .48). Separate ANOVAs were run to compare the groups' mean levels of impulsivity-related traits, as measured by the SUPPS-P subscales. The positive urgency scale violated the assumption of homogeneity of variance, so Welch's *F* test was run for that scale. No significant differences were observed on any of the subscales (*p*s > .13). Drinking measures (see Table 2), including past-year quantity per occasion, frequency, and frequency of intoxication; recency of last drink; the AUDIT; and the AEMax positive factor were compared across groups in separate ANOVAs (or Welch's *F* tests, when appropriate). Welch's *F* tests indicated differences that approached significance in the AEMax positive factor ($p = .06$) and AUDIT ($p = .10$). Post-hoc tests indicated that the alcohol image/expectancy word condition had a marginally lower AEMax positive factor mean than the neutral image/neutral word condition ($p = .06$); the AEMax positive factor was therefore included as a covariate in the analyses. Differences in the AUDIT means were less robust, although the alcohol image/expectancy word mean was somewhat reliably lower than the neutral image/expectancy word ($p = .12$) and alcohol image/neutral word (p = .11) conditions. A chi-square analysis comparing recency of last drinking episode indicated significant differences between groups, χ^2 (6, N = 129) = 15.93, p = .01. Analyses were initially run with recency of drinking as a covariate. Participants in the neutral image/expectancy word and alcohol image/neutral word conditions were more likely to drink within the last 24 hours than participants in the other conditions. Distributions of average past-year quantity per drinking occasion are displayed in Figures 3 and 4, and separated by gender; mean number of drinks per occasion were below standard "binge" levels (females: M = 3.03, SD = 1.37; males: M = 3.54, SD = 1.75).

As risk taking among college students often occurs in drinking contexts, it is conceivable that BART performance could be affected if it is completed during days of the week or hours of the day that are more proximal to drinking occasions. Thus, the mean time of day and day of the week participants completed the study were compared across the experimental groups. Time of day was converted to a continuous variable (minutes since 8 AM; the time of study completion in the final sample ranged from 8:40 AM to 4:20 AM), which facilitated easier analyses with other study variables. The mean time of day did not differ between groups, F(3, 137) = 1.20, p = .31. A chi-square analysis comparing the day of the week in which participants completed the study indicated significant differences, χ^2 (18, N = 141) = 31.86, p = .02. After adjusting for multiple comparisons, participants in the alcohol image/expectancy word condition were more likely to complete the task on Wednesdays compared to the other conditions. To maximize statistical power while controlling for day of the week (which would be limited when separating each condition by each day of the week), the day of week was converted to a dichotomous variable to reflect whether participation occurred on a Thursday, Friday, or Saturday (days of the week most associated with higher drinking levels in this age group; Del Boca, Darkes, Greenbaum, &

Goldman, 2004; Goldman, Greenbaum, Darkes, Brandon, & Del Boca, 2011), or on the other days of the week. This variable will be referred to as the "weekend/weekday" variable. This statistic was also significant, χ^2 (3, N = 141) = 9.13, p = .03; participants in the alcohol image/neutral word condition were significantly more likely to complete the study on Thursday, Friday, or Saturday than participants in the neutral image/neutral word and alcohol image/expectancy word conditions.

The group differences in theoretically relevant drinking and day of the week variables indicate that caution is warranted when interpreting the effects of the primes. The pattern of group differences was such that the participants who were theoretically less likely to be affected by alcohol primes—that is, lighter drinkers—were overrepresented in the alcohol image/expectancy prime condition. Moreover, this lighter drinking subsample would be expected to engage in less risk taking on the BART, even without the addition of alcohol-related primes.

Bivariate correlations among demographic, personality, and drinking variables are included in Table 3. Many significant correlations existed, as expected. This suggests that participants were attending to the questionnaire items.

BART Results

Prior to testing the primary hypotheses, the distributions of BART AMP were examined within each group for normality and outliers. Four total outliers—1 from each condition—were identified that were 2 interquartile range units from the mean. These values were Winsorized in the manner previously described in order to reduce their effects on group means. The resulting group distributions of BART AMP did not violate assumptions of normality. The distribution of BART AMP over the first 10 trials was also evaluated for normality and outliers in order to run a separate post-hoc comparison. One outlier was identified in the alcohol picture/neutral word condition, and was thus Winsorized. Each group's distribution did not violate assumptions of normality. The BART AMP of each condition (after adjusting for outliers) is included in Table 4.

It was hypothesized that risk taking would increase according to the amount of alcohol-related content in the primes, such that priming participants with alcohol-related stimuli (images and positive and arousing expectancy words) would lead to greater risk taking compared to priming participants with neutral, non-alcohol stimuli (images and words). After controlling for baseline AEMax positive factor and the dichotomous day of the week variable (recency of drinking was initially included as a covariate, but it did not significantly affect the relationship between risk taking and the primes, and was therefore not included in the main analysis reported here), planned comparisons between the neutral picture/neutral words (estimated marginal mean = 21.80 SE = 1.9) and alcohol picture/expectancy words conditions (estimated marginal mean = 22.68, SE = 2.1) indicated no significant differences in BART AMP, p = .75, 95% CI [-6.32, 4.55]. Planned pairwise comparisons between the other conditions indicated non-significant differences (ps > .15). Interestingly, the weekend/weekday variable was significant, $F(1, 135)$ = 10.21, p = .002, indicating that participants who completed the protocol on Thursdays, Fridays, or Saturdays tended to have higher BART AMP than those who completed the study on Sundays, Mondays, Tuesdays, or Wednesdays. This finding should be interpreted with caution, as certain conditions were overrepresented (through chance) on weekends. This finding, which was not predicted a priori and which the study was not designed to address, is examined more closely subsequent to the planned analyses.

To determine whether there was a differential effect on risk taking according to the type of prime (i.e., images versus words), the main effects of image and word type were compared in a 2 x 2 ANCOVA, after controlling for the AEMax positive factor and the weekend/weekday variable. Neither the image nor word type main effects were significant (*p*s > .59), indicating that neither alcohol-related pictures nor expectancy word primes alone increased risk taking levels. The image-by-word interaction statistic was also not significant, $p = .16$, indicating that the relationship between each type of prime and risk taking was not associated with the presence of another prime. While an interaction effect was not predicted a priori, the interaction would have been consistent with expectations had participants been significantly more risk prone when exposed to alcohol images and expectancy words together, compared to exposure to either of those primes in isolation.

To account for the possibility that a priming effect existed between these conditions, but weakened over time, BART AMP means over the first 10 trials were compared. After controlling for AEMax positive factor and weekend/weekday, the estimated marginal means of the neutral image/neutral word group ($M = 18.51$; SE = 2.17) and alcohol image/expectancy word group ($M = 19.17$; SE = 2.28) did not significantly differ, $p = .83$, 95% CI [-5.52, 6.84]. The overall relationship between priming condition and risk taking in the first 10 trials was similar to that observed for all 30 trials, suggesting that the absence of priming effects in the main analyses was not a result of priming effects that weakened over time.

An ancillary hypothesis was that the baseline AEMax positive factor would interact with priming condition to predict risk taking. When entered in a regression along with weekend/weekday, group (neutral images/neutral words or alcohol images/expectancy words), and baseline expectancies, the group-by-expectancy interaction term was not significant, $b = .01$,

$t(57) = .03$, $p = .98$, which indicates that the alcohol-related primes did not differentially affect participants with higher baseline positive expectancies.

Go/No-Go Results

The Go/No-Go data were assessed for outliers and normality before running the primary analysis. Seven participants had "Go" cue inhibition failure rates greater than 3 standard deviations from their group's mean; each of their error rates was .80 or higher, indicating they were incorrectly pressing the "Go" response on at least 80% of trials. These data points were removed from analyses. The resulting group means are included in Table 3. The resulting distributions were slightly non-normal (skewness approaching 2.5), and were thus log transformed for analysis.

As with the BART data, the effects of the priming conditions on Go/No-Go performance must be interpreted with caution, as the groups differed on relevant baseline drinking variables. Additionally, the study design did not account for order effects; the sequence of the BART and Go/No-Go was not counterbalanced.

It was predicted that inhibition errors on "Go" cue trials would increase according to the amount of alcohol-related content in the primes, such that priming participants with alcohol-related stimuli (images and positive and arousing expectancy words) would lead to a higher inhibition error rate compared to priming participants with neutral, non-alcohol stimuli (images and words). After controlling for baseline AEMax positive factor, the planned comparison between the neutral image/neutral word and alcohol image/expectancy word conditions was not significant, $p = .68$, 95% CI [-0.01, 0.02]. Comparisons among the other conditions were not significant (ps $>.53$), indicating that the primes did not affect response inhibition at any level.

Relationship Between and Among Behavioral Measures of Risk Taking and Impulsivity and Self-Report Measures of Drinking and Impulsivity

It was expected that the BART and Go/No-Go measures would be significantly correlated with scales from the SUPPS-P, along with measures of drinking. Neither BART AMP nor Go/No-Go inhibition error rates were associated with any of the SUPPS-P scales (*p*s > .39). BART AMP was not correlated with the AEMax positive factor or the drinking measures. Unexpectedly, Go/No-Go inhibition error rates were significantly negatively correlated with past-year frequency of drinking (Pearson $r = -.18$, $p = .046$), indicating that more frequent drinkers made fewer errors on the Go/No-Go task than less frequent drinkers. A second set of correlations was run using the entire sample of participants with reliable data, but regardless of drinking levels. The pattern of correlations remained unchanged, except for the Go/No-Go inhibition error rate correlation with past-year frequency, which became non-significant. This change in significance could signify that the original correlation was the result of type one error.

Manipulation Check: Alcohol Expectancy First Associate

The valence ratings (see Figure 5) of each group's first free associate were compared. It was predicted that, compared to participants in the neutral image and neutral word condition, a larger proportion of participants exposed to either the alcohol images or expectancy words would report positive first associates. A chi-square test comparing the valence of the first associates across the 4 conditions was not significant, χ^2 (6, $N = 127$) = 7.04, $p = .30$. The effect of Stroop condition was in the expected direction, such that a larger proportion of participants who were primed with expectancy words reported positive first associates than those primed with neutral words; however, this effect was not significant, χ^2 (2, $N = 127$) = 3.52, $p = .17$. Exploratory analysis, using data from participants with reliable data but regardless of their drinking levels, indicated the same pattern, but with significant results, χ^2 (6, N = 254) = 13.35, p = .04; this suggests that participants were attending to the verbal primes (Figure 6). As with the BART data, the free associate data must be interpreted with caution, and in the context of group differences in baseline drinking characteristics. Thus, it is difficult to conclude whether the free associate results are a result of the experimental manipulations, or whether they are an artifact of an unmeasured third variable.

Exploratory Analyses: Association Between BART Performance and Day of Participation

The association between increased risk taking on the BART and weekend participation was examined more closely, with the caveat that conclusions be tempered as a result of differences in relevant group characteristics. The estimated marginal means of BART performance from the previously run ANCOVA are further broken down by the weekend/weekday factor in Table 5. Risk taking was higher when participants completed the BART on Thursdays, Fridays, or Saturdays versus other days of the week, but this effect only approached significance for the alcohol image conditions (ps < .06). While this pattern of means is consistent with a context-dependent effect, in which images of alcohol become more salient primes on weekends, conclusions are necessarily limited due to the study design and several threats to internal validity. The day in which participants completed the study was not randomly assigned, so there could be unaccounted third variables responsible for the relationship between day of the week and risk taking. Of the drinking, personality, and time of day of study completion measures obtained, the only statistically significant difference between weekend and weekday participants was in the SUPPS-P lack of premeditation scale, such that weekend participants had higher (i.e., reflective of greater impulsivity) mean scores (M = 1.97; SD = 0.52) than weekday participants (M = 1.75; SD = 0.47). The correlation between lack of premeditation and risk taking was minimal and not significant (p = .54), however, which suggests that the weekend/weekday difference in lack of premeditation cannot explain why the weekend group was higher in risk taking. Nonetheless, there are other situational and participant-related variables that were not assessed that could potentially account for the differences in risk taking; in addition, baseline differences in group characteristics complicate the interpretation of the influence of prime, drinking history, and day of week on BART performance.

Exploratory Analyses: Subsample of Heavy Drinkers

It is conceivable that there is a higher likelihood for heavier drinkers to respond to the alcohol primes; that is, if the image or expectancy word cues were to promote risk taking or disinhibition, it would be expected to do so among the heaviest drinkers. One indicator of such a pattern would be significant positive correlations between drinking variables and the experimental outcomes (BART AMP and inhibition failures) in the conditions with expectancy word or alcohol image primes. However, no significant correlations existed between drinking variables and BART AMP or inhibition failures, indicating that risk taking or disinhibition was unrelated to drinking, regardless of the priming condition. It is also possible that the subclinical drinking characteristics of the sample masked the potential for priming effects. Thus, the primary outcomes were examined among participants whose AUDIT total scores were at or above the level (8) often cited in research studies as a cutoff for hazardous drinking (Table 6). This process significantly reduced the sample (N = 45), and interpretations remain difficult due to group differences in size and day of participation, with participants in the alcohol image/neutral word condition being significantly more likely to participate on Thursday, Friday, or Saturday than those in either of the neutral image conditions. After adjusting for 2 outliers in the BART data (1 low outlier in the alcohol image/neutral word and 1 high outlier in the neutral image/expectancy word conditions), the overall pattern remained similar (and non-significant): the lowest mean and median levels of risk taking were observed in the neutral image/neutral word condition). Due to the low frequency of errors observed in the Go/No-Go task across the sample, the Go/No-Go means in this reduced sample were not interpretable.

Table 1. Demographic and Personality Data Across Conditions.

	Neutral Scene & Neutral Words (n = 33)	Neutral Scene & Expectancy Words (n = 41)	Bar Scene & Neutral Words (n = 38)	Bar Scene & Expectancy Words (n = 29)
Gender, %				
Female, %	72.7%	82.9%	86.8%	82.8%
Ethnicity, %				
Caucasian	53.1%	56.1%	56.8%	53.6%
Hispanic	28.1%	34.1%	27.0%	21.4%
AA	9.4%	2.4%	8.1%	7.1%
Asian	9.4%	4.9%	5.4%	7.1%
Other	0%	2.4%	2.7%	10.7%
Age	19.97 (1.4)	20.51 (2.0)	20.16 (1.8)	19.82 (1.4)
% Thur/Fri/Sat*	27%	39%	61%	35%
SUPPS-P				
NU	2.55 (0.8)	2.33 (0.7)	2.35 (0.7)	2.12 (0.7)
SS	2.86 (0.6)	2.75 (0.8)	2.66 (0.6)	2.79 (0.6)
PU	1.96 (0.7)	1.91 (0.5)	1.94 (0.6)	1.74 (0.7)
LPer	1.74 (0.5)	1.65 (0.4)	1.83 (0.4)	1.71 (0.5)
LPrem	1.76 (0.5)	1.84 (0.4)	1.92 (0.5)	1.81 (0.6)

Note. Values represent means and standard deviations in parentheses, unless otherwise stated. AA = African-American. % Thur/Fri/Sat = percentage of participants who completed the study on a Thursday, Friday, or Saturday; SUPPS-P = Negative and Positive Urgency, Premeditation, Perseverance, and Sensation Seeking—Short Version; NU = negative urgency; SS = sensation seeking; PU = positive urgency; LPer = lack of perseverance; LPrem = lack of premeditation.

*$p < .05$.

Table 2. Drinking and Expectancy Data Across Conditions.

	Neutral Scene & Neutral Words (n = 33)	Neutral Scene & Expectancy Words (n = 41)	Bar Scene & Neutral Words (n = 38)	Bar Scene & Expectancy Words (n = 29)	p
Quantity	3.15 (1.4)	3.65 (1.5)	3.58 (1.5)	3.04 (1.2)	.196
Frequency	5.03 (1.0)	5.02 (1.2)	5.08 (1.3)	4.79 (1.2)	.775
Freq. of Intox.	3.21 (1.7)	3.85 (1.8)	3.24 (2.1)	2.83 (2.0)	.159
AUDIT	6.58 (4.4)	7.27 (3.5)	7.34 (4.4)	5.21 (2.7)	.102
AEMax Positive Factor	3.73 (0.8)	3.64 (0.5)	3.33 (1.0)	3.18 (1.1)	.060

Note. Values represent means and standard deviations in parentheses. Freq. of Intox. = Frequency of Intoxication; AUDIT = Alcohol Use Disorders Identification Test; AEMax = Alcohol Expectancy Multiaxial Questionnaire.

Table 3. Correlations Among Drinking and SUPPS-P Measures.

	1	2	3	4	5	6	7	8	9	10	11
1. Recency of Drinking	1										
2. AEMax Positive Factor	.12	1									
3. Frequency	.31**	.24**	1								
4. Quantity	.19*	.15	.19*	1							
5. Freq. of Intox.	.35**	.30**	.54**	.56**	1						
6. AUDIT	.29**	.29**	.48**	.57**	.68**	1					
7. LPrem	.14	.04	.20*	.28**	.23**	.32**	1				
8. SS	.13	.06	.13	.12	.15	.23**	.23**	1			
9. NU	.08	.12	.18*	.24**	.24**	.30**	.30**	.17*	1		
10. PU	.09	.10	.13	.27**	.26**	.36**	.33**	.30**	.62**	1	
11. LPers	.03	-.04	.09	.02	.00	.12	.43**	-.10	.07	.19*	1

Note. AUDIT = Alcohol Use Disorders Identification Test; AEMax = Alcohol Expectancy Multiaxial Questionnaire; SUPPS-P = Negative and Positive Urgency, Premeditation, Perseverance, and Sensation Seeking—Short Version; NU = negative urgency; SS = sensation seeking; PU = positive urgency; LPrem = lack of premeditation; LPers = lack of perseverance.

$^{*}p < .05$; $^{**}p < .01$.

Table 4. BART and Cued Go/No-Go Outcomes Across Priming Conditions.

	Neutral Scene & Neutral Words (n = 33)	Neutral Scene & Expectancy Words (n = 41)	Bar Scene & Neutral Words (n = 38)	Bar Scene & Expectancy Words (n = 29)
BART				
AMP	20.31 (9.4)	24.63 (11.7)	25.01 (10.5)	21.91 (11.5)
Explosions	5.15 (2.7)	6.71 (3.9)	5.90 (3.5)	5.83 (3.9)
AMP (Trials 1-10)	17.11 (11.0)	22.32 (13.9)	21.53 (11.5)	18.81 (11.6)
Cued Go/No-Go				
Inhibition Failures	.10 (.2)	.09 (.2)	.05 (.1)	.08 (.2)

Note. BART = Balloon Analogue Risk Task; AMP = Adjusted mean number of pumps.

Table 5. Estimated Marginal Means of BART AMP by Condition and Day of Participation.

Priming Condition	Day of Participation	Mean	SE	95% Confidence Interval		p
				Lower	Upper	
Neu. Scene/Neu. Word	Weekend (n = 9)	24.29	3.5	17.403	31.181	.220
	Weekday (n = 24)	19.06	2.2	14.780	23.342	
Neu. Scene/Exp. Word	Weekend (n = 16)	24.98	2.6	19.792	30.160	.910
	Weekday (n = 25)	24.60	2.1	20.456	28.741	
Bar Scene/Neu. Word	Weekend (n = 23)	29.19	2.2	24.881	33.500	.004
	Weekday (n = 15)	18.33	2.7	12.938	23.714	
Bar Scene/Exp. Word	Weekend (n = 10)	27.18	3.3	20.640	33.711	.053
	Weekday (n = 19)	18.82	2.4	13.988	23.649	

Note. Marginal means are estimates after controlling for AEMax Positive Factor. BART = Balloon Analogue Risk Task; AMP = Adjusted mean number of pumps; Neu. = Neutral; Alc. = Alcohol; Exp. = Expectancy.

Table 6. BART Outcomes Among Participants with AUDIT Total ≥ 8.

	Neutral Scene & Neutral Words (n = 11)	Neutral Scene & Expectancy Words (n = 15)	Bar Scene & Neutral Words (n = 13)	Bar Scene & Expectancy Words (n = 6)
BART				
AMP *M* (*SD*)	19.46 (9.3)	24.50 (13.3)	25.75 (5.8)	28.54 (21.74)
AMP Median	21.88	25.71	25.68	23.44

Note. BART = Balloon Analogue Risk Task; AMP = Adjusted mean number of pumps; AUDIT = Alcohol Use Disorders Identification Task.

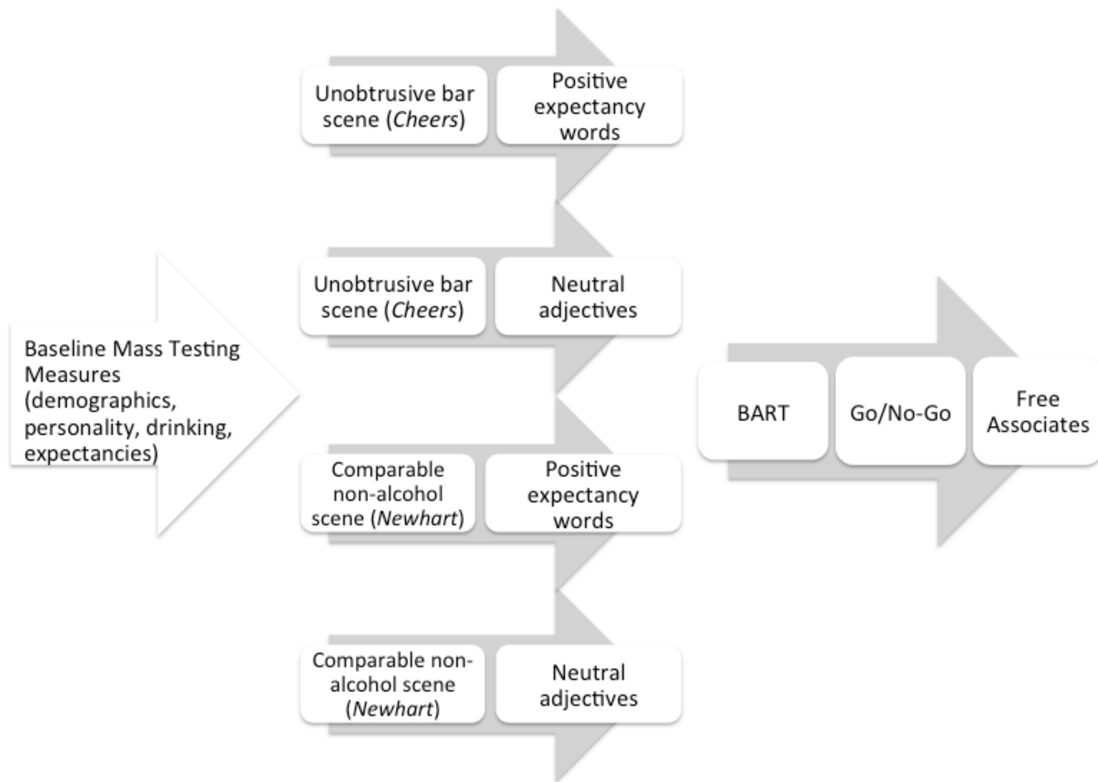

Figure 1. Study design, indicating the four different conditions to which participants were randomly assigned.

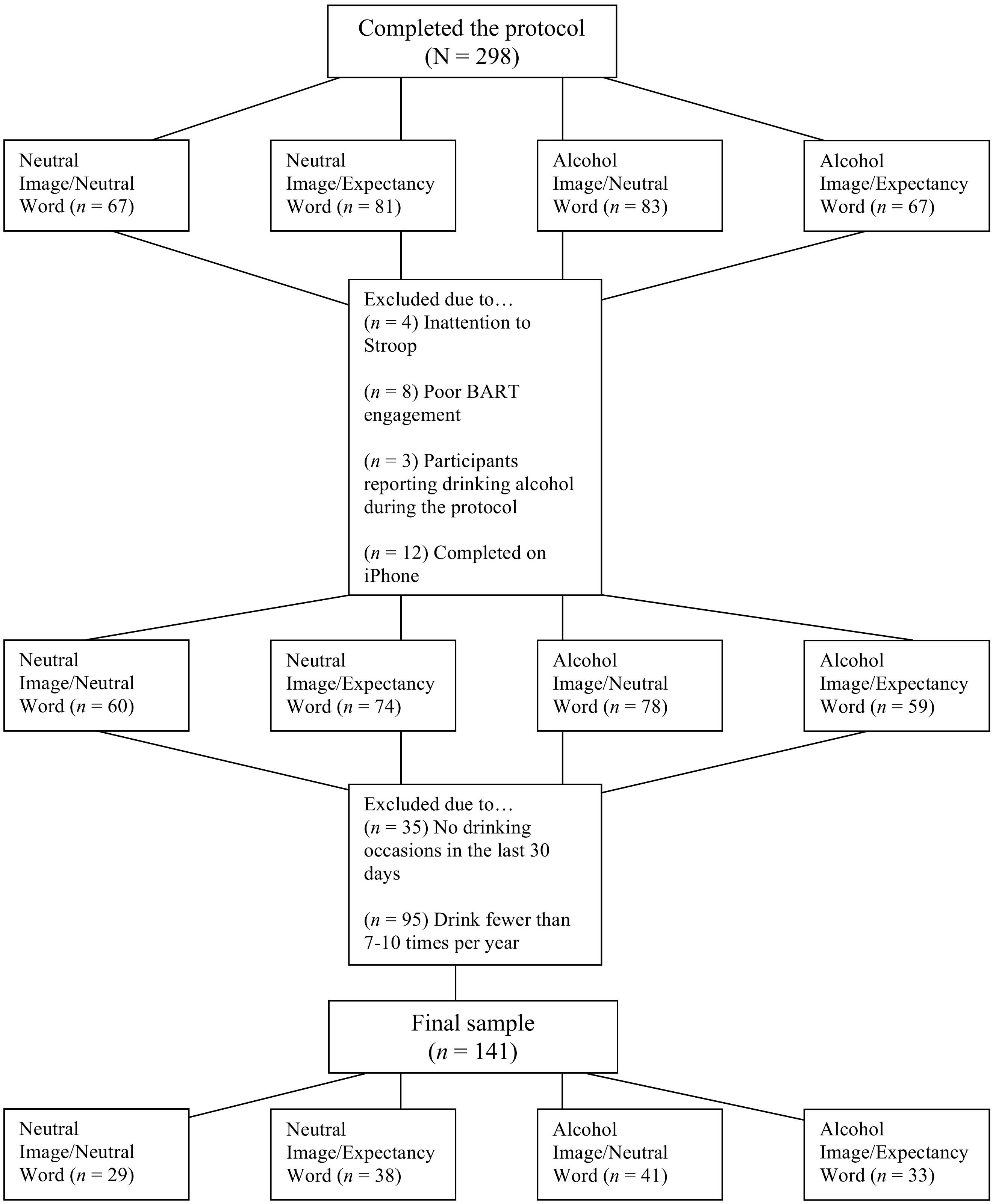

Figure 2. Participant flow diagram, documenting the number of participants excluded due to procedural issues or drinking characteristics.

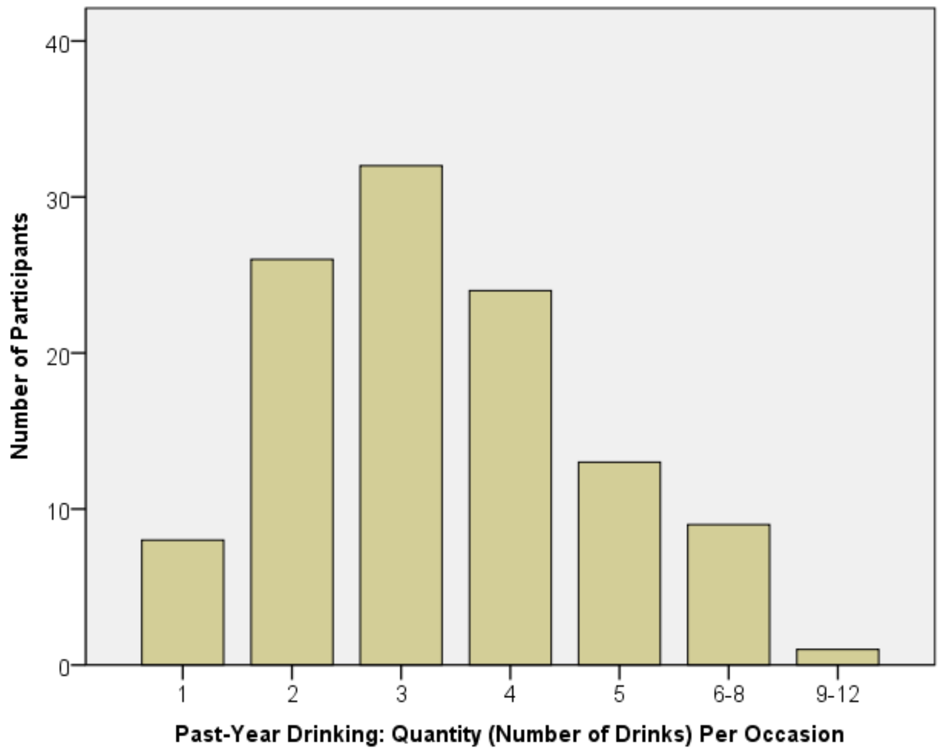

Figure 3. Distribution of past-year quantity per occasion among female participants.

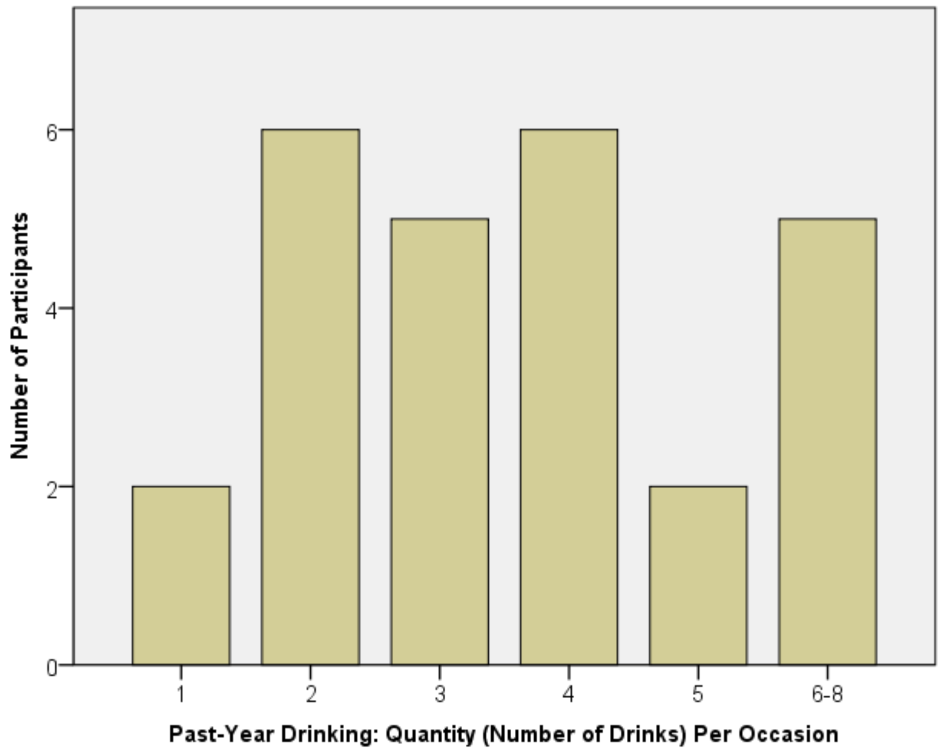

Figure 4. Distribution of past-year quantity per occasion among male participants.

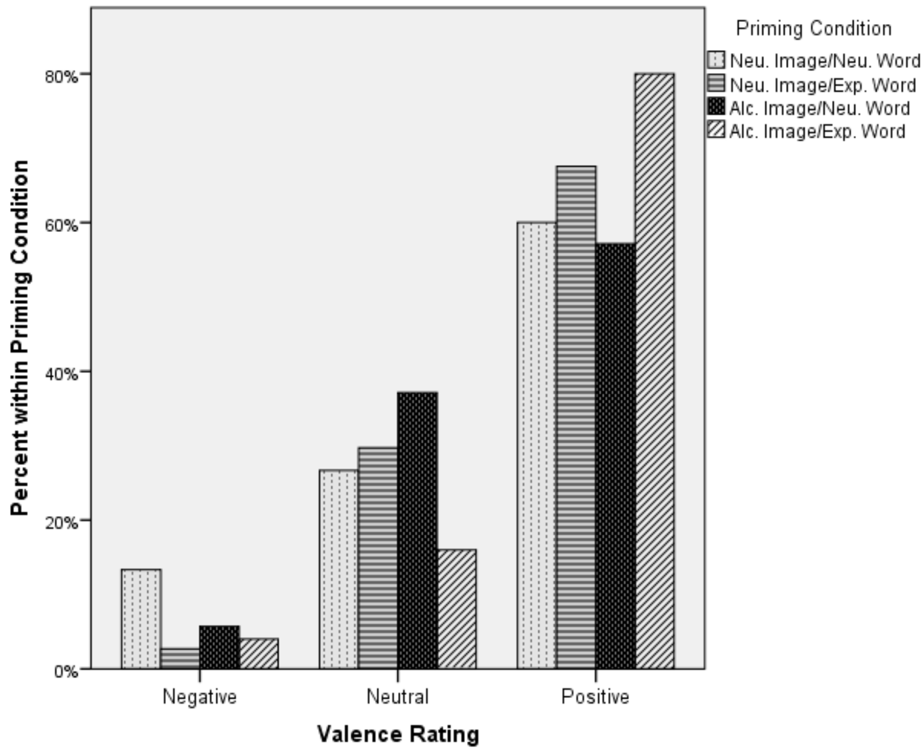

Figure 5. Among participants in the final sample of drinkers, percentage of participants within each priming condition who reported positive, neutral, or negative first associates. Neu. = Neutral; Exp. = Expectancy.

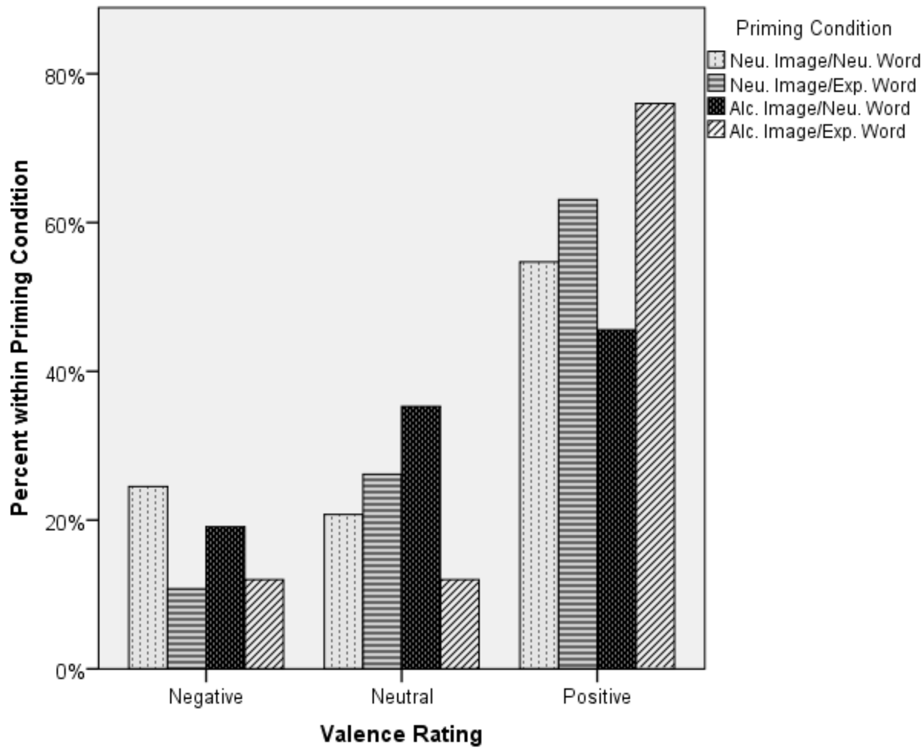

Figure 6. Among all participants (regardless of drinker level), percentage of participants within each priming condition who reported positive, neutral, or negative first associates. Neu. = Neutral; Exp. = Expectancy.

DISCUSSION

The primary objective of this study was to examine whether implicit visual alcohol and verbal alcohol expectancy primes could elicit greater risk taking and impulsivity (response disinhibition) on the BART and Cued Go/No-Go task, respectively, than neutral, non-alcohol related primes. Moreover, it was hypothesized that the levels of risk taking and impulsivity would increase linearly, according to the amount of alcohol content in the priming conditions: participants primed with neutral images and neutral words were expected to demonstrate the lowest levels of risk taking and impulsivity, followed by the neutral image and expectancy word condition, the alcohol image and neutral word condition, and the alcohol image and expectancy word condition. The central hypothesis was not supported, as participants exposed to alcohol images and expectancy words were not significantly riskier on the BART or more impulsive on the Cued Go/No-Go than participants exposed to neutral images and words. In addition, the linear effect of priming condition on BART AMP and Cued Go/No-Go was not significant. Exploratory analysis revealed that BART AMP tended to be higher among participants who participated on Thursdays, Fridays, or Saturdays, compared to other days of the week. Importantly, results from all analyses must be interpreted with caution, as significant differences existed among the groups' baseline drinking and expectancy data, as well as the days of the week in which participants completed the study. These significant differences indicated that random assignment produced group characteristics that were not sufficiently equivalent for controlled comparisons. It is difficult to determine, for example, whether the day of the week context interacted with the priming effects of the pictures to increase risk taking, or whether the weekend effect was the result of an accounted, systematic difference in group characteristics.

Understanding the group differences in baseline drinking and expectancies may help inform interpretations of the BART data; specifically, the pattern of drinking levels may have suppressed the potential for priming effects in the alcohol image and expectancy word condition. The alcohol image and expectancy word condition tended to have the lowest mean levels of drinking compared to the other conditions. The underlying theory driving the present study would suggest that participants who have less significant drinking histories would also be less sensitive to alcohol-related primes. Thus, the groups' drinking levels were unbalanced against the linear, stepwise pattern of increased risk taking predicted across priming conditions. While this pattern could potentially explain why risk taking in the alcohol image and expectancy word condition was not significantly higher than the neutral image and neutral word condition, it is also possible that BART performance is not sensitive to the primes in this study.

We also investigated whether the present sample's drinking characteristics—the mean of which was below hazardous levels—could have masked any effects of the primes. Heavier drinkers would be theoretically more likely to respond to the alcohol primes than lighter drinkers, so the inclusion of lighter drinkers could have made detecting the priming effects more difficult. Thus, the BART and Go/No-Go data were re-analyzed among participants who reported hazardous levels of drinking. The resulting Go/No-Go data were not interpretable, given the smaller sample and low frequency of errors. The pattern of BART results was similar to the original sample, in that participants who received no type of alcohol or expectancy word prime tended to have the lowest levels of risk taking. This finding was again not significant, however, and drawing inferences was further complicated by the low number of heavy drinkers in the alcohol image and expectancy word condition.

An unexpected association emerged, with higher mean levels of risk taking being observed among those who participated on Thursdays, Fridays, or Saturdays ("weekends"), compared to other days of the week, although this finding, too, must be interpreted in light of the study design and group differences. Greater risk taking on weekend days was not predicted a priori simply because it was unclear whether there would be sufficient power to detect such a pattern; rather, it was examined as a possible third variable that could affect the relationship with risk taking if there were group differences in day of participation. This pattern existed in three of the four conditions, but only approached significance for the two alcohol image conditions; risk taking in the neutral image/expectancy word condition was similar on weekends and weekdays. While this relationship appears to be consistent with a context-dependent effect, in which images of alcohol scenes become more salient and have greater priming effects during weekends, the lack of random assignment to days of the week means that a third variable could potentially explain this relationship. In other words, the participants who chose to participate on Thursdays, Fridays, or Saturdays could be characteristically different from participants who chose other days, and this difference could be accounting for the increases in risk taking. In the present sample, the available personality and drinking data could not clearly account for the weekend/weekday differences: the only significant difference between the Thursday, Friday, and Saturday participants and other day participants was in the lack of premeditation variable, such that weekend participants reported higher (i.e., more impulsive) levels. However, lack of premeditation was also unrelated to risk taking, so it is unclear whether it could account for the weekend/weekday effect on risk taking. Ultimately, it is difficult to make strong conclusions about the weekend effect, given the failure of random assignment and the possibility of unaccounted systematic group differences.

Boundary Conditions: Participant Engagement to the Primes and Behavioral Tasks

Engagement to the primes. While there were multiple sources in the data to evaluate participants' engagement to the tasks, it cannot be ruled out that variability in attention to the primes and tasks contributed to the lack of priming effects. The online-based Inquisit software used to run the protocol reports item- and summary-level response data from each participant. This information was used to identify participants who may not have been attending to the tasks. Attention to the verbal primes—which were presented in a Stroop task—was assessed by examining reaction time and number of correct responses. Each item requires a rapid response, and although the task of identifying the color of a word is itself not cognitively demanding, it does require focus on which key to press for each of the four colors; in other words, participants cannot correctly complete the task while dividing their attention with non-test stimuli. This is significant, as it indicates that participants who correctly responded to the Stroop items in a certain amount of time were, at a minimum, focusing on the word stimuli. Moreover, the alcohol expectancy free associate task results are consistent with this interpretation: the groups exposed to positive expectancy word primes tended to report a higher proportion of positive first associates compared to the other conditions. Attention to the visual primes was not assessed, however, and thus cannot be ascertained; nonetheless, those whose performances on other tasks (i.e., the BART and Stroop, and Go/No-Go) were indicative of poor engagement were removed from all analyses, so the likeliest offenders were removed.

Engagement to the BART and Go/No-Go. In addition to the primes, evaluating the BART and Go/No-Go data was critical for establishing boundary conditions necessary for making inferences about the underlying constructs (i.e., risk taking and response inhibition): if participants were not engaged in the tasks, one cannot assume task outcomes reflect risk taking or impulsivity. Engagement in the Go/No-Go task was easier to assess, as accurate performance requires attention; by removing participants with extreme error rates (e.g., participants who respond incorrectly to 90% of the trials; this was less than 5% of the sample), it can be assumed that at least the majority of the data are valid. On the other hand, it cannot be ruled out that participants were inattentive to the BART, despite the inspection of the data. Inferring lack of engagement is difficult to determine based on the BART output, so a conservative approach was taken in the present sample. It is conceivable that participants who inflated each balloon a few times were simply "clicking through" the task (note: this was atypical in the present study). However, it is also possible that this reflects an extreme level of risk aversion. Alternatively, a participant's mean balloon pump count could be similar to the overall mean, but they could have been mindlessly clicking without concern for reward or loss. The only criterion to confidently identify poor engagement was when participants failed to pump a single time on balloon trials.

Online Versus Laboratory, In-Person Methods of Assessment

Given that published BART and Go/No-Go research has typically involved laboratory-based, in-person (as opposed to online) assessments, it is relevant to make careful comparisons of the present BART and Go/No-Go results with data from published studies to explore whether there were any indicators of anomalous data. While caution is warranted in comparing group means across samples, mean BART AMP in the present study (23.1 across the four conditions) was somewhat lower than mean AMP (35.60 ± 5.93) in a meta-analysis of 22 BART studies with non-clinical samples (Lauriola et al., 2013). The relatively lower levels of engagement in risk taking in the present sample, despite the presence of alcohol cues, could suggest that participants were less motivated or less engaged in the present sample; this is significant, as it could preclude the potential for priming effects. In the Go/No-Go data, the average rate of inhibition failures was similar to that observed in other undergraduate samples (e.g., Marczinski, 2017), suggesting the present data at least met the minimum boundary conditions; however, the shorter duration of the task in the present study (about seven minutes) relative to published studies (about 15 minutes) may have limited the variability in the present data. Overall, while the somewhat lower mean levels of risk taking relative to published data could be indicative of the differences in assessment modality, a more systematic and controlled comparison between online and in-person studies is necessary.

Ultimately, it is difficult to accurately conclude whether alcohol cues increase risk taking on the BART or impulsivity on the Go/No-Go task based on the present results, as important unanswered questions remain about the validity of assessing these constructs online. Moreover, the alcohol expectancy priming paradigms on which this study was based were established in laboratory settings; it is unclear whether these effects would translate to online methods. To effectively demonstrate subtle, context-sensitive psychological phenomena, experimental control is necessary. The participant's experience during the same protocol can be fundamentally different in a laboratory, relative to online. In the laboratory, there are tacit social pressures to engage in the role of a participant. Online, there is no experimenter (implicitly or explicitly) commanding attention to the task; the participants' data might be consistent with manipulation checks which indicate compliance, but the mental or behavioral processes (and the depth of them) that produced that score could differ in subtle ways that are not fully appreciated. Thus, systematic comparisons between online and in-person methods of the experimental paradigms and behavioral tasks in this study would be useful.

The absence of priming effects could be an artifact of methodological error, but it could also be related to the mild nature of the primes. The primes in, and the design of, the present study were influenced by a previous study in this laboratory (Roehrich & Goldman, 1995), in which compound cues of visual and verbal alcohol-related stimuli implicitly primed in vivo drinking. However, the primes and study design differed in important ways. Firstly, while the present study used still images from the television show *Cheers*, the earlier study used a specific *Cheers* video clip (with audio) that was chosen in part for its comedy. A video scene with audio is inherently more engaging and involves more sensory stimulation than a series of still images, which could make activation of alcohol concepts in memory (and subsequent behavior consistent with expectancies, such as risk taking or disinhibition) more likely to occur. Secondly, the earlier study included a social component: participants were exposed to the stimuli and consumed the drinks in groups. This is important, as the anticipatory cognitions theorized to underlie alcohol-related behaviors are closely linked with social reward (Goldman et al., 2010); in the prior study, exposing the primes and measuring the behavior in a social context (albeit an artificial one) may have approximated the conditions in which expectancy activation is more likely to occur. The social component is important when considering alcohol-related risk behaviors, as well: some of the most dangerous drinking behavior occurs as a function of social gatherings, such as spring break or fraternity events (e.g., Patrick & Lee, 2012). Consistent with this relationship, recent studies have demonstrated that risk taking on the BART increases in the presence of peers (Cavalca et al., 2013; Erskine-Shaw, Monk, Qureshi, & Heim, 2017; Reniers et al., 2017). Presenting a less stimulating visual prime in the absence of a social context could have contributed to the null findings in the present study. Given the relationship between alcohol use, social rewards, and risk taking, examining the interaction between alcohol expectancy priming and social setting on BART performance could be more revealing.

Implications and Conclusions

While limitations related to baseline differences in group characteristics suggest caution is warranted, the greater levels of risk taking observed on weekends in the alcohol image condition could have important theoretical and practical implications. Firstly, it suggests risk taking propensity could vary as a function of context, and is not an immutable, fixed trait; this is consistent with studies demonstrating experimental manipulations of BART performance (e.g., Acheson et al., 2007; Baker & Maner, 2009; Cavalca et al., 2013; Erskine-Shaw et al., 2017; Euser et al., 2011; Lighthall et al., 2009; Reniers et al., 2017). Although selection effects—rather than time as context—cannot be ruled out as moderating this effect, the apparent increased sensitivity to alcohol image primes on weekends would be consistent with conceptualizations of alcohol cognitions as dynamic and responsive to context. In a practical sense, the findings suggest that investigation of the BART could benefit from using remote data collection methodologies—as is commonly done with ecological momentary assessment studies—which could enable researchers to assess how important contextual factors (e.g., time, location) affect alcohol cognitions and risk behavior. Nonetheless, these implications are speculative.

Important questions remain about the role of alcohol-related context in risk taking behaviors. Taken at face value, the present results seem to indicate that alcohol primes do not influence risk taking or response disinhibition: group means of BART and Cued Go/No-Go outcomes did not differ. It is not clear whether this is a valid conclusion, however, because of methodological issues. Baseline characteristics differed between groups, so it is not clear whether the alcohol cues failed to increase risk taking or disinhibition because those participants were less risky to begin with (and less likely to respond to the primes); alternatively, it is not evident whether the alcohol primes did not elicit risky or impulsive behavior because of the mild nature of the primes (i.e., perhaps more engaging stimuli could have elicited risk taking or impulsivity, indicating that alcohol context does affect these behaviors), or whether alcohol cues of any kind are insufficient in eliciting risky or impulsive behavior. Evaluating the degree to which the online format of this study impacted the results is also unclear, as there have not been systematic comparisons between online and in-laboratory procedures for the priming methods or behavioral tasks used in this study. Research to systematically compare the two formats could help clarify the present findings. In addition, future research should more closely investigate the finding of increased risk taking observed on weekends, and whether alcohol cues have a stronger effect on risk taking when presented in proximity to drinking occasions. Further investigation of the contingencies that underlie risky behavior and drinking could ultimately improve understanding and prediction of risk taking behavior.

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