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Anticipatory Motivation for Drinking Alcohol: An In-Vivo Study

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by

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ABSTRACT

Numerous studies from various research groups have already shown the usefulness of alcohol expectancies as predictors of long-term future alcohol consumption. The present study extends this line of research by directly testing whether alcohol expectancies measured in the moment using free association are useful as predictors of alcohol consumption in the next few hours. An ecological momentary assessment (EMA) procedure was used to examine how alcohol expectancies might fluctuate during days in which many people expect to drink (e.g. Fridays, Saturdays) and how these fluctuations in alcohol expectancies might predict future drinking and/or co-vary with important contextual variables during that same day. The results supported our main hypothesis that increases in positively-valenced alcohol expectancies would be observed a few hours to minutes before engaging in alcohol consumption. These findings provide further evidence that anticipatory information processing is a key part of the motivational system that directs future behavior, and that probing expectancies in real-time can be useful for predicting alcohol consumption in the near future.

CHAPTER ONE:

INTRODUCTION

Excessive alcohol consumption (i.e. heavy drinking and alcohol use disorders) has a significant negative impact on communities in the United States every year. This negative impact ranges from thousands of people who are killed in alcohol-impaired driving accidents to billions of dollars lost due to medical expenses and wasted earnings (Research Society on Alcoholism, 2015). Given this negative impact, it is important to understand the variety of motivational factors that influence the decision to drink alcohol excessively. One such factor that has consistently been found to influence, and be influenced by, alcohol consumption is alcohol expectancy (Sher, Grekin, & Williams, 2005; Jester et al., 2014). Since expectancy processes are theorized to guide basic behavioral functioning and even sensory perception (Bar, 2011; Lupyan & Clark, 2015), it is reasonable to assume that expectancy processes are involved in the full range of alcohol-related behaviors, ranging from abstinence or moderate usage to pathology and excessive consumption.

What are Expectancies?

Generally, expectancies are thought to be based primarily on associations among content that is stored in our memory, while the associations themselves are based on our past experiences (Bar, 2011; Goldman, 2002; Goldman & Reich, 2013). An expectancy, or “expectation”, occurs when a piece of information stored in memory that is activated further activates other connected pieces of information (i.e. those pieces that are similar in some way; “associations”); these activated associations then generate predictions that prepare us for future circumstances by anticipating what we will experience next (i.e. “expectancy”) (Bar, 2011; Goldman, 2002; Goldman, Darkes, Reich, & Brandon, 2010). Since these predictions reflect our prior knowledge about the world, expectancies may be at the core of the predictive processing that is hypothesized to underlie our perceptual experiences of the world (Lupyan & Clark, 2015; Goldman et al., 2010). In the context of reward learning and motivated behavior, expectancies are thought to be the cognitive representations of the causal relationship between engaging in a behavior and receiving a rewarding outcome (Berridge, 2001). Thus, the expectancy process and reward learning are vital to an organism’s survival because it allows the organism to adapt and adjust its behaviors in order to prepare for upcoming situations, both near (e.g. the next moment) and distant (e.g. a year from now), which increases its odds of survival (Goldman, 2002; Goldman et al., 2010).

Given that associations and expectancies are based on past experiences, it is apparent that expectancies are influenced by culture, in that they can represent information acquired from immediate social contexts, family environments, and larger communal systems. That is, expectancies are shaped by an individual’s past experiences with his environment, which includes the socially shared information that is learned from engaging with other people (i.e. culture; Laland, Odling-Smee, & Myles, 2010). It should not be surprising that culture shapes expectancies, since substantial evidence indicates that culture has strongly influenced human biology and psychology, ranging from genetics and brains to concepts and behavior (Laland, Odling-Smee, & Myles, 2010; Kitayama & Uskul, 2011; ojalehto & Medin, 2015). Indeed, specific expectancies related to alcohol use have been found to be socially-shared and transmitted (Donovan, Molina, & Kelly, 2009). The existence of alcohol expectancies in children before they ever engage in alcohol consumption also provides strong evidence that expectancies are socially-learned (Christiansen, Goldman, & Inn, 1982; Jester et al., 2014). Therefore, expectancies result from the activation of associations that are stored in memory that then anticipate future situations and allow an organism to adapt to maximize survival; in humans, this entire process is strongly influenced by an individual's culture. Consequently, the phrase "alcohol expectancies" can be thought of simply as applying this entire expectancy process to the domain of alcohol consumption.

Many theories of substance use and addiction include some form of the expectancy concept as an important feature in the development and continuation of substance use disorders, although they do not always explicitly use the term "expectancy". For instance, the sensitized incentive salience theory of addiction suggests that sensitization ("hypersensitivity") to drug stimuli and drug effects is at the core of addiction, but the behavioral manifestations of this sensitization are strongly influenced by whether or not a drug is expected in a given context (Robinson & Berridge, 2003; Robinson & Berridge, 2008). Proponents of the incentive salience view have also argued that both incentive salience and cognitive expectation processes can simultaneously motivate behavior and are involved in reward learning (Berridge, 2001). In the stimulus-response ('habit') learning theory of addiction, conditioned stimuli and reinforcers that predict (i.e. anticipate) the rewarding effects of a drug eventually initiate and maintain compulsive drug seeking behaviors (Everitt & Robbins, 2005). Even the opponent-process theory of addiction, which emphasizes the role of a withdrawal/negative affect stage in an addiction cycle, also includes a stage that highlights the addict's preoccupation with and anticipation of a drug's rewarding effects (Koob & Le Moal, 2008b). Another hypothesis of the opponent-process theory, namely that allostatic changes fail to return to the original homeostatic state because of "anticipated" challenges to homeostasis, also assumes that an expectancy process is in operation (Koob & Le Moal, 2008a; Goldman, 2002). Similarly, alcohol expectancies play a key role in some relatively recent dual-process theories of alcohol consumption and addiction (Moss & Albery, 2009; Wiers et al., 2007; Stacy & Wiers, 2010). Therefore, although theories of substance use and addiction do not always explicitly use the word "expectancy", the common theme of anticipatory information processing (e.g. "expectancy", "anticipation", "prediction", "preoccupation", etc.) is often included as an important feature in those theories (see Reich and Goldman [2014] for a discussion of different words that have been used to describe the common theme of anticipatory information processing for alcohol use). Thus, there is a large body of scientific evidence and theory to suggest that what people expect drinking alcohol will do for them before they start drinking on any given day has a significant impact on their decisions related to drinking alcohol.

Are Expectancies Implicit or Explicit?

Expectancies can be measured either explicitly (i.e. with conscious awareness) or implicitly (i.e. without conscious awareness) depending on the methodology used for a given study (Goldman, Reich, & Darkes, 2006). In the context of substance use, however, expectancies are sometimes described as merely explicit, verbal declarations or propositional beliefs that an individual has about using a particular substance (e.g. Robinson & Berridge, 2003; Wiers et al., 2007; Wiers & Stacy, 2012; Stacy & Wiers, 2010). On the other hand, others have argued that expectancies can operate implicitly, as well as explicitly (Moss & Albery, 2009; Goldman, Reich, & Darkes, 2006; Reich, Below, & Goldman, 2010). Even those who disagree with conceptualizing expectancies as implicit associative processes still acknowledge that some methods of measuring expectancies can gauge implicit associations if there is a strong connection in memory between the stimulus (e.g. alcohol) and the expectancy (e.g. "having fun"; Wiers & Stacy, 2012). Since expectancies are based primarily on associations in memory and those associations can be activated either implicitly or explicitly (Nelson, McKinney, Gee, & Janczura, 1998), it seems unnecessary to restrict associations only to the realm of implicit processing and expectancies only to the realm of explicit processing. Similarly, the predictive processing underlying our perceptual experiences of the world is thought to be built upon generally non-conscious expectations (Lupyan & Clark, 2015; Goldman et al., 2010). Therefore, good theoretical reasoning and empirical evidence suggests that expectancies can be measured both explicitly and implicitly and can reveal both explicit and implicit cognitive processes.

Context and Expectancies

Although alcohol expectancies measured at a single point in time have often been used as long-term predictors of future alcohol use (e.g. Christiansen, Smith, Roehling, & Goldman, 1989; Jester et al., 2014; Colder et al., 2014), substantial evidence shows that alcohol expectancy activation can be highly dependent on the immediate context (Wall, McKee, & Hinson, 2000; Wall, McKee, Hinson, & Goldstein, 2001; Monk & Heim, 2013a; Monk & Heim, 2013b; LaBrie, Grant, & Hummer, 2011; Reich, Goldman, & Noll, 2004; Reich, Noll, & Goldman, 2005; Krank, Wall, Stewart, Wiers, & Goldman, 2005; Cox, Van Enkevort, Hicks, Kahn-Weintraub, & Morin, 2014). These studies have found that contextual variables such as room type (sitting in a bar vs. office room), word presentation (reading “beer” vs. “milk”), and even physical balance (feeling balanced vs. unbalanced) can influence whether or not alcohol expectancies become activated in memory. Additionally, a relatively recent social-attributional theory of alcohol’s effects on mood predicts that the anticipation of unstable, self-relevant negative outcomes in a given social context will result in enhanced mood when drinking alcohol (Fairbairn & Sayette, 2014). Thus, Fairbairn and Sayette suggest that the relationship between alcohol and mood is moderated by the anticipation of the social context’s potential outcomes. Furthermore, since both the amount of alcohol consumed and the types of alcohol-related problems experienced vary depending on the drinking context (Freisthler, Lipperman-Kreda, Bersamin, & Gruenewald, 2014), it is reasonable to predict that cognitive variables that are thought to influence drinking, such as expectancies, will also co-vary with the drinking context. This prediction is also consist with findings from rat studies which suggest that environmental contexts where drug-seeking was initially reinforced (i.e. “learned”) with drug administrations can renew drug-seeking behaviors even after the extinction of those same behaviors in a different environmental context; this seems to occur despite the fact that the drugs themselves are not administered to reinforce the drug-seeking behaviors during re-exposure to the context where the initial learning took place (Crombag, Bossert, Koya, & Shaham, 2008). Therefore, cognitive variables related to alcohol consumption, such as expectancies, should be especially salient in environmental contexts where individuals have previously learned to engage in alcohol-seeking behaviors. Further, alcohol expectancies in particular should be sensitive to contextual stimuli that are associated with alcohol, because the perception of those contextual stimuli should lead to the anticipation of future alcohol consumption, regardless of whether any alcohol is actually present.

Measuring Expectancies In-vivo

However, many of the studies that have looked at the relationship between alcohol expectancies and context have usually been conducted in laboratory settings or other fairly controlled environments that have questionable generalizability to real-life, in-vivo settings. But at least one study has examined the covariation of alcohol expectancies and social/environmental contexts in-vivo using ecological momentary assessment (EMA; discussed further below) (Monk & Heim, 2014). They found that, as predicted, alcohol expectancies do fluctuate in the real world depending on a person's social context (e.g. alone vs. with friends) and environmental context (e.g. bar vs. work). Based on these findings, the authors concluded that alcohol expectancies should not be considered merely static cognitions; instead expectancies should be viewed as fluctuating in synchrony with a person's immediate context, which is consistent with both expectancy theory as a whole and the numerous laboratory studies showing alcohol expectancies to be sensitive to contextual differences (Goldman et al., 2010).

Although Monk and Heim's (2014) study showed important and novel findings for using the EMA measurement procedure in alcohol expectancy research, other important questions related to gauging alcohol expectancies in-vivo remain open for exploration. First and foremost is the question of whether probing alcohol expectancies in-vivo is a useful indicator of the motivational states that guide alcohol-related behaviors in the near future. Since anticipatory cognitive processes have already been shown to be useful as predictors of long-term alcohol use, it seems reasonable to hypothesize that these same anticipatory processes will be active proximal to short-term alcohol use. A valuable extension to the alcohol expectancy literature might come, therefore, from a demonstration that expectancies measured in-vivo can reliably predict alcohol consumption in the immediately following hours.

Second, the timing of repeated-measurements is critical to any longitudinal design, including EMA studies; whether or not a relationship between two variables is detected is highly dependent on how much time passes between one measurement and the next (Collins & Graham, 2002). For example, if the next measurement is taken too soon, then it is possible that not enough time has passed for the influence of a predictor variable (e.g. initiation of drinking) to be seen in the outcome variable (e.g. alcohol-related problems); on the other hand, if the next measurement is taken too late, then it is possible that the influence of a predictor variable (e.g. being with friends who are drinking) on the outcome variable (e.g. initiation of drinking) has already peaked and declined back to an unnoticeable level (Collins & Graham, 2002). Monk and Heim (2014) acknowledge some of these issues when they note that their study did not collect measurements between the hours of 11pm and 1am, which can be prime drinking time for many drinkers on the weekends. Therefore, the time of day when the measurements occur may affect the observed relationship between alcohol expectancies and contextual variables. Further, Monk and Heim's (2014) study used measurement intervals that were randomized by 15-minute blocks within 3-hour periods, so that the time between one measurement and the next could be as short as 30 minutes or as long as 6 hours. Although such a measurement timing schedule may be ideal for simply examining the co-occurrence of contextual variables and alcohol expectancies very generally over the course of a day or week, it is possible that some important relationships between context and alcohol expectancies were missed due to the timing of the measurements, such as whether certain alcohol expectancies immediately precede and/or follow drinking and the occurrence of important contextual variables. The research questions and hypothesized relationships between variables should direct not only the methodological design, but also how the data is structured and what kinds of statistical analyses are used in longitudinal research (e.g. in the case of non-experimental designs, which variable is used as a predictor and which is used as an outcome) (Shiffman, 2014).

Lastly, how alcohol expectancies are measured could also impact the findings of naturalistic, in-vivo measurements. As discussed previously, alcohol expectancies can be measured implicitly or explicitly. Although implicit and explicit measures of alcohol expectancies share a lot of the same variance in predicting alcohol use/problems, each type of measure does seem to have some unique ability to predict alcohol use/problems independent of the other (Reich et al., 2010). This finding that implicit and explicit measures of alcohol expectancies may uniquely predict alcohol consumption is consistent with the idea that both implicit and explicit cognitive processes play important and at least partially distinct roles in substance use and addiction (Moss & Albery, 2009; Wiers et al., 2007; Stacy & Wiers, 2010). Because the findings of Monk and Heim (2014) are based on a small number of more explicit alcohol expectancy questions taken from an expectancy questionnaire, it is possible that measures which probe the more implicit operation of alcohol expectancies (e.g. free association; discussed further below) could also be useful for examining the covariation of alcohol expectancies and contextual variables.

The Present Study

To our knowledge, no published study has tested whether alcohol expectancies measured in-vivo can reliably predict future alcohol consumption later on in the same day. Such a study would be a valuable test of alcohol expectancy theory, given that a key proposition of expectancy theory is that anticipatory information processing and the resulting anticipatory "mindset" (i.e. the collection of predictions that are activated in the mind at any particular moment; Bar, 2011) are crucial for decision making and guiding future behavior (Reich & Goldman, 2014). Numerous studies from various research groups have already shown the usefulness of expectancies as predictors of long-term future alcohol consumption. The present study extends this line of research by directly testing whether alcohol expectancies measured in-vivo and in the moment (i.e. state-like expectancies) are useful as predictors of alcohol consumption in the next few hours.

In keeping with recent exhortations to use electronic technologies to monitor alcohol-related behaviors and cognitions in real-time and naturalistic environments (Chung & Hilton, 2014), the general purpose of the present study was to measure alcohol expectancies outside of the laboratory and in natural settings using repeated, in-vivo measurements. More specifically, the goal was to capture alcohol expectancies shortly before, during, and after the occurrence of drinking and/or contextually important drinking variables (e.g. being with friends who are drinking). Another goal was to obtain more implicit measurements of alcohol expectancies in naturalistic environments, since there is substantial evidence (discussed previously) to suggest that implicit measurements of alcohol expectancies are sensitive to contextual variables. Implicit measurements of alcohol expectancies may be more sensitive to context than explicit measurements because explicit measurements are more likely to include context within the questions themselves (e.g. “Having a few drinks was a nice way to celebrate special occasions.”) and suggest a more trait-like response from participants, while implicit measurements often do not include as much contextual information. Repeated in-vivo assessments of alcohol expectancies essentially guarantee that contextual variables will vary, and thus allow for a closer look at the covariation of contextual variables and implicitly measured alcohol expectancies. More concretely, we examined how alcohol expectancies fluctuated over the course of an evening in which many people expect to drink (e.g. Friday, Saturday nights), and how these fluctuations in alcohol expectancies predicted future drinking and/or co-vary with important contextual variables during that same evening.

Since expectancies are theorized to be part of the motivational system that directs future behavior (Bar, 2011; Goldman, 2002; Goldman et al., 2010) and positive alcohol expectancies measured a year or more in advance have been empirically shown to predict future alcohol consumption (Christiansen et al., 1989; Jester et al., 2014; Colder et al., 2014), it is reasonable to expect that this predictive relationship will be seen in a short time interval as well; and so increases in positively-valenced alcohol expectancies should be observed a few hours to minutes before engaging in alcohol consumption. If a buildup of positively-valenced alcohol expectancies can be reliably detected in individuals who go on to consume alcohol later in the day, then this finding would support the idea that anticipatory information processing happening in the moment is involved in determining which behaviors occur in the near future. This hypothesis is consistent with an EMA study that found that drinkers with high positive sociability expectancies measured only at baseline self-reported increased levels of positive affect in the hours immediately preceding the consumption of their first alcoholic drink in a given day (Treloar, Piasecki, McCarthy, Sher, & Heath, 2015). This hypothesis was also supported by studies that found enhancement drinking motives (which is a cognitive construct that is very similar to positive alcohol expectancies) measured only at baseline can predict future drinking levels and moderate the relationships between contextual variables, drinking levels, and positive appraisals of drinks that were measured using EMA techniques (Smit, Groefsema, Luijten, Engels, & Kuntsche, 2015; Gautreau, Sherry, Battista, Goldstein, & Stewart, 2015; Piasecki et al., 2014).

We also hypothesized an increase in positively-valenced alcohol expectancies when people are in contexts where they have learned from past experiences to expect heavy alcohol consumption (e.g. being with others who are drinking, at a bar, a club, a house party, etc.) as compared to contexts where they have learned to not expect heavy alcohol consumption (e.g. being alone, in school, at work/home) (Wall et al., 2000; Wall et al., 2001; Monk & Heim, 2013a; Monk & Heim, 2013b; Monk & Heim, 2014; LaBrie et al., 2011; Reich et al., 2004; Reich et al., 2005). This hypothesis is consistent with EMA studies that have found that self-reported levels of positive-negative affect ("happy" – "sad") and stimulation-sedation ("excited" – "sluggish") tend to co-vary with drinking levels and the environmental/social contexts in which drinking occurs (Treloar et al., 2015; Piasecki, Wood, Shiffman, Sher, & Heath, 2012; Gautreau et al., 2015). We also hypothesized that the relationship between alcohol expectancies and contextual variables would be moderated by an individual's typical drinking level (light/moderate vs. heavy), such that heavy drinkers would show the strongest relationship between positively-valenced alcohol expectancies and contextual variables when compared to light/moderate drinkers (Reich et al., 2004; Reich et al., 2005). Heavy drinkers likely have stronger associational memory networks related to alcohol, since almost by definition they engage in alcohol consumption more frequently than other drinkers and therefore have had more experiences with which associations can form. A placebo-controlled study also found that heavy drinkers report more stimulating and rewarding (i.e. positive) subjective responses to alcohol consumption when compared to lighter drinkers (King, de Wit, McNamara, & Cao, 2011). Thus, heavy drinkers should be more sensitive to environmental stimuli that could activate alcohol expectancies, and it is likely that these activated alcohol expectancies would be more stimulating and positively valenced.

Lastly, exploratory analyses examined whether an association between positively valenced alcohol expectancies and future alcohol consumption was moderated by baseline levels of explicitly measured alcohol expectancies (i.e. trait-like expectancies), religiosity, and facets of impulsivity. Religiosity and religious group affiliation has been tied to both alcohol expectancies and alcohol consumption (Galen & Rogers, 2004; Patock-Peckham, Hutchinson, Cheong, & Nagoshi, 1997). Similarly, some facets of impulsivity, such as sensation seeking, negative urgency, and positive urgency, have been associated with alcohol consumption and alcohol-related problems (Smith et al., 2007; Cyders et al., 2007; Cyders, Littlefield, Coffey, & Karyadi, 2015). It is also possible that the more trait-like alcohol expectancies measured at baseline could influence the hypothesized relationships, since explicitly and implicitly measured expectancies can uniquely predict alcohol use/problems independent of each other (Reich et al., 2010). Therefore, it is plausible that religiosity, impulsivity, and trait-like alcohol expectancies measured at baseline would moderate the anticipatory relationship between momentary alcohol expectancies and future alcohol consumption in the same day.

CHAPTER TWO:

METHODS

Design

Ecological momentary assessment (EMA) is a particularly useful design strategy to measure alcohol expectancies and other variables repeatedly over time in natural environments (Shiffman, Stone, & Hufford, 2008). EMA and related methodological designs (e.g. ambulatory assessment) use repeated sampling of a person's current/recent behaviors, cognitions, environments, etc. while the person is in their natural environment (Shiffman et al., 2008; Trull & Ebner-Priemer, 2012). Such repeated samplings (or "events") can capture the real-world dynamic processes and temporal relationships between variables of interest (Neal et al., 2006; Wray, Merrill, & Monti, 2014; Beckjord & Shiffman, 2014; Shiffman et al., 2008). Being able to measure cognitive processes in natural environments has been useful for testing whether results found in laboratory-based studies replicate in real-world experiences (e.g. emotion and psychopathology; Bylsma & Rottenberg, 2011). Other widely noted advantages of EMA include both better ecological validity and more reliable data due to less recall bias in self-reports (Beckjord & Shiffman, 2014; Shiffman et al., 2008). When modern technologies (e.g. mobile phones, biosensors, social media, GPS) are used to collect the repeated samples, EMA can become an especially powerful measurement tool due to increased precision (e.g. timely response; electronic time-stamps; predetermined assessment schedule) and temporally continuous measurements (Chung & Hilton, 2014; Neal et al., 2006; Cohn, Hunter-Reel, Hagman, & Mitchell, 2011; Trull & Ebner-Priemer, 2012; Wray et al., 2014; Greenfield, Bond, & Kerr, 2014; Freisthler et al., 2014; Harris & Knight, 2014). Therefore, although moving out of the laboratory may reduce "control" over confounding variables and potentially increases measurement error, the advantages of the EMA design still make it particularly well-suited for acquiring evidence to help answer our research questions.

Given that EMA has already been used successfully in alcohol and other substance use research (Shiffman, 2009; Wray et al., 2014), we also used an EMA approach that takes advantage of readily available technology (i.e. mobile phones) to test our hypotheses regarding alcohol expectancies, context, and alcohol consumption (for a brief discussion on using mobile phones for EMA, see Kuntsche and Labhart, 2014). Specifically, participants in our study were prompted using their mobile phones to provide information regarding their current alcohol expectancies, affect, context, and drinking status. These prompts occurred repeatedly over the course of a Tuesday, Friday, and Saturday in a week during the academic semester. Tuesday was chosen as a baseline comparison for Friday and Saturday because college age adults tend to consume much less alcohol on Tuesdays relative to Fridays and Saturdays (e.g. Del Boca, Darkes, Greenbaum, & Goldman, 2004). Friday and Saturday were chosen because several studies have shown that these nights are when the highest percentage of many North American and European young adults drink alcohol and consume the largest quantities of alcohol (Tremblay et al., 2010; Wood, Sher, & Rutledge, 2007; Cleveland, Mallett, White, Turrisi, & Favero, 2013; Del Boca et al., 2004; Reich, Cummings, Greenbaum, Moltisanti, & Goldman, 2015; Finlay, Ram, Maggs, & Caldwell, 2012; Kuntsche & Labhart, 2012; Wray et al., 2014). The late morning to evening hours (10:00am – 1:00am) were chosen because the evening hours are when alcohol use and heavy drinking are most likely to occur for young adults, which is supported by findings from a couple of EMA studies with Swiss college students by Kuntsche and colleagues (Kuntsche & Labhart, 2012; Kuntsche & Labhart, 2013; Thrul & Kuntsche, 2015; Kuntsche, Otten, & Labhart, 2015). These researchers successfully utilized hourly mobile phone assessments to collect alcohol consumption and contextual information (e.g. location, number of people present) from participants over the course of multiple weekend evenings, demonstrating the feasibility of repeated, hourly mobile phone assessments of alcohol use with young adults. Some of their findings include different hourly drinking patterns during the evening (e.g. stable vs. accelerated) and different hourly drinking patterns on different days of the week; they also found that having more friends present at a given time point during the evening was associated with more self-reported alcohol consumption at that time point. Relatedly, Twitter posts in the United States with content related to alcohol intoxication have been found to peak during the evening hours of 9pm to 2am on the weekends (West et al., 2012). However, the assessment prompts in our study began at 10:00am because our goal of testing the anticipatory relationship of alcohol expectancies and future alcohol consumption requires assessing alcohol expectancies before drinking begins. Therefore, we used mobile phone assessments that were delivered repeatedly in 3 hour intervals over the course of Tuesdays, Fridays, and Saturdays between the hours of 10:00am and 1:00am in order to maximize our chances of capturing the anticipatory relationship of alcohol expectancies and future alcohol consumption, as well as the general covariation of alcohol expectancies, contextual variables, and alcohol consumption.

Measures

Demographics. The general demographic information collected included age, gender, ethnicity, and religious affiliation. Simple face valid questions were used to gather the demographic information (i.e. “What is your age?”, etc.).

Baseline Measurements. Baseline measurements that were gathered included explicit trait-like alcohol expectancies, facets of impulsivity, religiosity, and alcohol drinking history. Explicit alcohol expectancies were measured using the Alcohol Expectancy Multiaxial Assessment short form (A.E. Max; Goldman & Darkes, 2004). Averaged scores can range from 0 (“Never”) to 6 (“Always”). We initially calculated the averages for each of the 3 higher order factors of the A.E. Max short form (i.e. sedating, negative, positive-arousing) reported by Goldman and Darkes (2004); however, since the sedating and negative factors were strongly correlated ($r = 0.58$), we combined those two factors into one. The two resulting A.E. Max factors, negative-sedating and positive-arousing, had good internal reliability, $\alpha = 0.89$ and $\alpha = 0.92$ respectively (all reliability estimates were obtained from data collected in the present study).

Facets of impulsivity were measured using the short version of the UPPS-P Impulsive Behavior Scale (SUPPS-P; Cyders et al., 2015). Averaged scores can range from 1 (“Agree Strongly”) to 4 (“Disagree Strongly”). The SUPPS-P contains 3 higher-order factors: emotion-based rash action ($\alpha = 0.83$), sensation seeking ($\alpha = 0.72$), and deficits in conscientiousness ($\alpha = 0.79$). These three factors are theorized to tap into different facets of the larger impulsivity construct, and higher scores on these factors indicate greater impulsivity.

Religiosity was measured using the Duke Religion Index, with higher scores indicating greater religiosity (Storch et al., 2004). Because the first two items are scored differently (1 to 6, instead of 1 to 5 like the other three items), averaged scores can range from 1 to 5.4. The religiosity factor had good reliability (α = 0.91).

Alcohol drinking history was measured using general quantity-frequency questions developed by researchers at the Centers for Disease Control and Prevention that were modified to distinguish binge drinking from "usual" drinking, since this modification may produce a more accurate estimate of a person's drinking habits (Stahre, Naimi, Brewer, & Holt, 2006). The questions, based on those from Stahre et al. (2006), were as follows: "During the past 30 days, how many days per week did you have at least one drink of any alcoholic beverage? Considering all types of alcoholic beverages, how many days during the past 30 days did you have 5 or more drinks on an occasion? On the days when you drank less than 5 alcoholic beverages, about how many drinks did you drink on average?" The modified quantity-frequency index is simply the product of the frequency of non-binge drinking days and the average non-binge quantity, plus the product of the frequency of binge-drinking days and 5 (Stahre et al., 2006; 5 is the cut-off for binge-drinking using this index); the result was then divided by 30 to produce the drinks per day index. This index served as the alcohol drinking history variable.

The A.E. Max factors, SUPPS-P factors, religiosity, and alcohol drinking history variables were each grand-mean centered so that 0 represents the average score across all participants, positive scores indicate that a person is above the sample average for that variable, and negative scores indicate that a person is below the sample average for that variable.

In-Vivo Alcohol Expectancies. Alcohol expectancies were measured using a word association task known as free association, which is theorized to tap into implicit memory (Nelson et al., 1998; Nelson, McEvoy, & Dennis, 2000; Stacy, Ames, & Leigh, 2004; Stacy, Ames, & Grenard, 2006; Rooke, Hine, & Thorsteinsson, 2008). Free association often involves simply asking participants to provide the first words that come to mind when responding to open-ended prompts, such as "Alcohol makes me _____" (Stacy et al., 2004; Stacy et al., 2006; Reich & Goldman, 2005; Dunn & Goldman, 2000; Reich, Ariel, Darkes, & Goldman, 2012; Nelson et al., 2000). The probability of responding to the prompt with any given word (e.g. "sick") is thought to measure the relative strength of implicit memory associations to a target word/concept (e.g. "alcohol"; Nelson et al., 1998; Nelson et al., 2000). Relative strength refers to the notion that the strength of association between two concepts in memory (i.e. the probability of responding to a free association prompt with a particular word) at any given time is heavily dependent on a person's past experiences and immediate context at the time of responding, which makes free association essentially a measure of state (vs. trait) cognitions. Being able to probe state cognitions is also why free association is ideal for measuring both the momentary anticipatory motivational processes that may guide future alcohol consumption and the covariation of alcohol expectancies and drinking-related contextual variables.

To measure the anticipatory processing system more precisely, the typical free associate instructions were modified to include future-oriented contingencies and wording. Therefore, participants were instructed to "Think about the rest of your day. Fill in the blanks with the first word that you think of. Answer as fast as you can. Drinking alcohol will make me ___________." This free associate prompt served as an implicit measure of state alcohol expectancies in this study. Participants received the latter sentence of the prompt 5 times in a row during each assessment time point in order to obtain a maximum of 5 free associates per assessment time point.

Word association tasks have already been successfully used to measure alcohol-related cognitions (including expectancies) that predict alcohol use, indicating their usefulness as implicit measures of alcohol-related cognitions (Rooke et al., 2008; Stacy et al., 2004; Stacy et al., 2006; Dunn & Goldman, 2005; Reich & Goldman, 2005; Reich et al., 2010; Goldman, Reich, & Darkes, 2006). Alcohol-related cognitions measured using a word association task have also been found to differentiate among heavy and light drinkers in a college student sample (Stacy, Leigh, & Weingardt, 1997), but not in a sample of high-risk youths (Stacy, Galaif, Sussman, & Dent, 1996). Having more drinking experiences and imagining different contexts have predicted the strength of association in memory between positive outcomes and alcohol-related cognitions measured using word association tasks (Stacy, Leigh, & Weingardt, 1994). Further, implicitly measured alcohol-related cognitions can be positioned on semantic dimensions that reflect valence (positive – negative) and arousal (exciting – sedating); the positions of alcohol-related cognitions along these dimensions have been found to predict alcohol drinking levels (Wiers et al., 2007; Dunn & Goldman, 2005; Reich & Goldman, 2005; Reich et al., 2012; Goldman, Reich, & Darkes, 2006), although there are likely to be cultural differences in the precise patterns of prediction (Mahoney, Graham, Cottrell, & Kim, 2011).

Free associates have often been scored using group-level probabilities which are determined by dividing the number of participants who respond with a given free associate by the total number of participants (e.g. Nelson et al., 2000; Reich & Goldman, 2005). Although this approach is useful for obtaining a general descriptive survey of which free associates are most common for a given sample, this approach has two weaknesses that make it undesirable for our study. First, measuring within-person changes requires scores for individual participants, which group-level probabilities do not provide. Second, unique free associate responses generated by a large group of participants can number in the hundreds or thousands (i.e. hundreds or thousands of variables), which is problematic for analyses and often requires using only a few of the most frequently mentioned free associates. Including only the most frequent free associates may result in a substantial loss of useful information obtained by the free associate prompts. Given the weaknesses of using general group-level probabilities, it is preferable to use a scoring method for free associates that both aggregates scores across unique free associates and produces scores for individual participants.

To quantify free associate responses in our study, two different scoring schemes were combined. The first scoring scheme was to rate each free associate word along a valence dimension. These ratings were obtained from unpublished data from a longitudinal study in which the drinking levels and alcohol-related cognitions of roughly 600 college students at this same university were tracked for 5 years (see Reich et al., 2015). During that study, students were asked to rate each free associate word from "extremely unpleasant" to "extremely pleasant" (i.e. valence). Scores could range from 1 to 7, with higher scores indicating more pleasantness (i.e. more positive valence) and lower scores indicating more unpleasantness (i.e. more negative valence). The mean pleasantness ratings of each free associate word from that study were used as the valence scores for the free associate words in this study. These valence scores were then centered around the scale mean (= 4) to allow for negative valence scores, because lower scores indicate unpleasantness (i.e. negative valence) and not merely less pleasantness (i.e. positive valence). This distinction is important when applying the salience weights to the valence scores (see next section).

The second scoring scheme uses a simple saliency index (Smith's *S* index) developed by cognitive anthropologists to identify the most salient items of any cultural-cognitive domain when a free-listing task is used (Smith, 1993; corrected formula in Sutrop, 2001; Thompson & Juan, 2006; see Appendix A). This salience index was used for two reasons. First, it is intuitive that the first words mentioned on an open-ended list represent the most salient concepts in mind at that moment (Smith, 1993). Second, it is theorized that the first words produced in response to free-association tasks are more reliable indicators of the relative strength in memory between the concept represented by the free associate prompt and the concepts represented by the free associate responses (Nelson et al., 2000). Using this salience index effectively gives more weight to the first free associate responses provided by a participant at any given time point. The index uses the length of a participant's free associate list (i.e. total number of free associates generated) and the rank of a given free associate word (i.e. the position of the word in the list) to create scores ranging from 0 to 1, in which a score of 0 represents a free associate word that was not listed by the participant and a score of 1 represents the first free associate word that was listed by the participant. Other words listed after the first word get a score between 0 and 1.

The valence score for each word is then multiplied by the salience score for that word, so that the valence scores are essentially weighted by the salience score. For each time point, the salience-weighted valence scores for all free associates that a person listed were summed together to create a total valence score for that time point. Although 8% of free associates could not be assigned a valence score even after data cleaning because of idiosyncratic responses, summing the scale-mean centered valence scores effectively treats these unscored free associates as having a neutral valence (= 0). Finally, these total salience-weighted valence scores were person-mean centered, so that 0 represented the average valence score for each person across the entire study, positive scores indicate that a person is above their own average (i.e. more positively valenced), and negative scores indicate that a person is below their own average (i.e. more negatively valenced). This person-mean centered salience-weighted valence score was the primary measure of in-vivo alcohol expectancies. We also included the valence person-means as a covariate in order to account for any between-person differences in general alcohol expectancy valence, and thus further distinguish within-person changes in alcohol expectancy valence from between-person differences (a.k.a. "contextual effects" model; Feaster, Brincks, Robbins, & Szapocznik, 2011). The person-mean centered salience-weighted valence scores of the free associate responses had good reliability ($\alpha = 0.71$). Using person-mean centered scores allows for showing change at a particular measurement moment relative to that person's own centered mean (i.e. within-person changes).

In-Vivo State Affect. Although general state affect has been shown to be predictive of future alcohol consumption during the course of a day (Treloar et al., 2015), we hypothesized that alcohol expectancies would add incremental prediction over general state affect, since general affect and alcohol expectancies likely operate simultaneously (and interactively) to motivate alcohol-related behaviors. State affect was measured by the following prompt adapted from Treloar et al. (2015), “Rate how you feel right now.” Participants then rated how “excited”, “happy”, “sad”, and “distressed” they currently feel on a Likert scale from 0 (“not at all”) to 5 (“extremely”). The scores for “excited” and “happy” were averaged to create a positive affect score (“happy” and “excited” were strongly correlated, $r = 0.67$), and the scores for “sad” and “distressed” were averaged to create a negative affect score (“sad” and “distressed” were strongly correlated, $r = 0.62$). These affect scores were person-mean centered, so that 0 represents the average positive (or negative) affect score for each person across the entire study, positive scores indicate that a person is above their own average positive mood (or negative mood), and negative scores indicate that a person is below their own average positive mood (or negative mood). The positive and negative affect person-means were also included as covariates to account for general between-person differences in positive and negative affect throughout the study (again, see “contextual effects” model; Feaster et al., 2011).

In-Vivo Alcohol Consumption. Recent alcohol consumption was measured by asking participants how many and what type of alcoholic beverages they have consumed in the past three hours, including any beverages they are currently drinking. The prompt asked, “How many of the following drinks have you drank in the past 3 hours? Type in 0 for all if you have not been drinking alcohol.” A list appeared below this question, where participants entered how many of each type of alcoholic drink they consumed. The alcoholic beverage types that were listed include beer, hard liquor (e.g. shots), wine, and “other”. Next to each type of beverage, there was an image of that particular drink taken from the National Institute on Alcohol Abuse and Alcoholism’s pocket guide for alcohol screenings (NIAAA, 2015).

Although we collected the number of drinks, we chose to dichotomously categorize alcohol consumption as either any drinking in the past 3 hours (= 1) or no alcohol consumed in the past 3 hours (= 0). Alcohol consumption was dichotomized partly because participants were allowed 1 hour and 30 minutes to complete the survey after it was sent, but the question asked for alcohol consumption in the past 3 hours. If a participant completed consecutive surveys either too close or too far in time from each other, it is possible that participants who interpret the prompt very literally will either double count the number of drinks they've had or may not report drinking that has occurred. Alcohol consumption reported at the previous time point was included as a covariate to also adjust for double counting drinks. Dichotomizing the drinking variable and including its value from the previous time point helps to somewhat ameliorate the problem of possible contamination resulting from double counting drinks or missing drinking that occurred, because the inherent dependency of reported drinking between a contaminated time point and the previous time point may be accounted for by the covariate.

In-Vivo Context. In keeping with the methods used in the previous alcohol EMA studies (e.g. Monk & Heim, 2014; Kuntsche et al., 2015; Piasecki et al., 2012; Smit et al., 2015), self-reports about the participants' environmental context and social context were used to measure contextual variables. Social context was measured using the following question, "How many men are you with right now?" and "How many women are you with right now?" To answer, participants select a single integer ranging from 0 to 6-or-more. Environmental context was measured using a fill-in-the-blank question, "Where are you right now?" Responses were coded into two categories for analysis: alcohol related (= 1) and non-alcohol related (= 0). Alcohol related locations included bars, pubs, clubs, parties, and football games. Using this coding scheme, 121 observations (2.4 %) were categorized as being ‘alcohol-related’ and 4,930 (97.6%) were categorized as ‘not alcohol-related’ across all participants and time points. The questions for assessing these variables were intentionally few and short to minimize the potential for reactivity due to having longer assessment instruments which could alter the participants’ cognitions and/or behaviors.

Participants

The participant sample (*N* = 426) consisted of undergraduate students enrolled in psychology courses from a large public university in the southeast United States who reported consuming any alcohol in the past 30 days and who currently use a smartphone. Although college students are possibly the least representative sample for making generalizations about the larger human population (i.e. WEIRD; see Henrich, Heine, & Norenzayan, 2010), college students and college-age young adults are among the U.S. demographic groups that are most likely to participate in recent alcohol use, binge alcohol use, and heavy alcohol use (Substance Abuse and Mental Health Services Administration, 2014; Naimi et al., 2003; Merrill & Carey, 2016). Therefore, college students and college-age young adults seem to be the participants who are most likely to engage in alcohol consumption (and extreme alcohol consumption) on any given day, which is a useful characteristic for our study, since more true score variation in alcohol consumption allows for more reliable estimates of the covariance between alcohol consumption and other variables.

The participant sample was predominantly females (76%) with a mean age of 21 (*SD* = 3.3). Although such a disproportionate gender ratio may raise concerns about the generalizability of our findings for males, our relatively large sample size means that there were still about 100 males in this dataset. The males also did not have more missing data than the females (see "Missing Data" section below), which increases our confidence in the reliability of any statistical inferences made about males in our sample. Age was centered so that 0 represents the youngest age (18 years old) in our sample. Gender was coded so that females were the reference group (females = 0, males = 1). The ethnic breakdown of the sample was 59% White, 24% Hispanic, 8% Black, 6% Asian, and 3% other.

Procedure

The demographic questions and baseline measures were administered during the mass-testing that Introduction to Psychology students completed during the semester. When participants signed-up for the study on the online SONA system, they gave informed consent and entered in their primary cellphone numbers to which they received the study measures at the appropriate times. Participants received text messages with a web-link to the online survey which was hosted by Qualtrics, an online survey system commonly used by universities, organizations, and businesses. Qualtrics has survey templates that are compatible with smartphones and tablet sized electronics. The text messages with the web-links were sent using the Qualtrics mailer, which allowed for large numbers of text messages to be sent simultaneously to many participants according to a predetermined time schedule. The text messages were sent at 3 hour intervals between 10:00am and 1:00am (i.e. at 10:00am, 1:00pm, 4:00pm, 7:00pm, 10:00pm, and 1:00am) on Tuesdays, Fridays, and Saturdays during the academic school year. Time of day was centered so that 0 corresponds to 10am and 5 corresponds to 1am; day of the week was centered so that 0 corresponds to Tuesday and 1 corresponds to Friday and Saturday (i.e. weekday vs. weekend). Each participant only participated for one week (i.e. only 1 Tuesday, Friday, and Saturday triad), since we were primarily interested in hourly changes happening within a day (as opposed to differences between days). We avoided assessing participants on weekends which have been found to have atypical drinking levels and may add confounding influences to our results (e.g. Thanksgiving, New Year's Eve, "Guavaween", home football games, Spring Break; see Del Boca et al., 2004).

All participants received the prompt at roughly the same moment, allowing for delays in wireless signals. Participants had 1 hour and 30 minutes to complete the survey for that time point before the survey link expired. When participants opened up the survey on Qualtrics, they completed the alcohol expectancy free associate question first, then the alcohol consumption question, then the environmental context question, then the social context question, and then the state affect questions. Once they started the survey, it took most participants 2 minutes or less to complete all the questions (~75% across all participants and time points) and only 5% of the surveys were completed in more than 7 minutes. Students received course credit based on how many EMA prompts they completed.

Statistical Analyses

To examine the covariation of in-vivo alcohol expectancies, alcohol consumption, contextual variables, and baseline demographics, multilevel modeling (a.k.a. hierarchical linear models, random effects models, mixed effects models) was used to analyze the between-person and within-person variance in alcohol consumption (Curran & Bauer, 2011; Bauer, 2011;

Hertzog & Nesselroade, 2003). These analyses can test whether individuals who overall have more positively valenced alcohol expectancies are more likely to drink alcohol at any given hour (i.e. between-person differences); they can also test whether an individual who experiences an increase in positively valenced alcohol expectancies during the night, relative to their own average expectancy valence level, will tend to drink more alcohol as well (i.e. within-person changes). Furthermore, time-lagging key predictors of interest (e.g. expectancies, affect) was used to establish temporal precedence, which is crucial for supporting the causal claim that changes in alcohol expectancies directly influence alcohol consumption.

Analyses were conducted using PROC GLIMMIX and PROC MIXED in SAS (9.4) software. For PROC GLIMMIX analyses, the estimation method used was the maximum likelihood Laplace approximation, and the degrees of freedom were calculated using the "between-within" option. For PROC MIXED analyses, the estimation method used was maximum likelihood, and the degrees of freedom were also calculated using the "between-within" option. Maximum likelihood estimation provides unbiased parameter estimates when data is missing at random, and less biased estimates than traditional techniques when data is missing not at random (Baraldi & Enders, 2010).

Assumptions. The assumptions of normality and homoscedasticity for the level-2 residuals were assessed using univariate descriptives and visual assessment (i.e. boxplots, Q-Q plots, histograms). Non-normality and heteroscedasticity were observed for the level-2 residuals in all models. To account for non-normality and heteroscedasticity in the residuals, the empirical standard errors ("sandwich - classical") provided by the SAS software were used to decrease the potential for a Type I error.

Time-Lagged Predictors. In order to strengthen the causal test of our time-varying predictors, alcohol expectancy valence, positive mood, and negative mood were time-lagged so that the scores obtained for these variables at the time point immediately before (i.e. 3 hours before) were matched to alcohol consumption at the next time point ($T - 1$). For example, alcohol expectancy valence measured at 1pm was matched with alcohol consumption at 4pm. As mentioned before, we also included alcohol drinking status (yes or no) at the previous time point as a predictor of drinking at the next time point to account for the autocorrelation of drinking status. This approach was used for methodological reasons (see Methods section) and to control for the possibility that observed relationships between expectancies at one time point and drinking at the next time point were spurious byproducts of the carryover of drinking across adjacent assessments (i.e. "behavior predicts behavior").

Proposed Models. A separate multilevel analysis was conducted for each hypothesis. All multilevel analyses were 2-level analyses, with time of day (level-1) nested within persons (level-2). The following variables were time-varying variables and could be considered level-1 (hourly level) predictors: lagged alcohol expectancy valence, lagged positive mood, lagged negative mood, lagged drinking status, alcohol-related contexts, time of day, and day of the week. The following variables were time-invariant and could be considered level-2 (person level) predictors: age, gender, past 30-day drinking, baseline alcohol expectancies, baseline impulsivity, religiosity, and the person-means for alcohol expectancy valence, positive mood, and negative mood. For each outcome variable, a 2-level unconditional model with time of day (level-1) nested within persons (level-2) was created to determine how much variability was within persons and between persons (ICC).

The main hypothesis (i.e. increases in positively-valenced alcohol expectancies should be observed a few hours to minutes before engaging in alcohol consumption) and the exploratory hypotheses regarding moderation of the main hypothesis by baseline alcohol expectancies, impulsivity, and religiosity, were tested using multilevel logistic regression because the outcome, alcohol consumption, was treated dichotomously. Thus, we were interested in predicting whether any alcohol consumption had occurred, but not the amount of alcohol consumption.

The equation for the multilevel logistic regression of the main hypothesis is shown in Appendix B. Drinking_{ti} is whether alcohol had been consumed during the past 3 hours for time of day t and participant i, and π_{0i} is the log odds of drinking for an 18 year old female at 10am on a weekday when all other covariates are at 0 for participant i. Time of day was treated as a random effect (π_{1i}), so that each participant had their own change in the log odds of drinking during the course of the day. The fixed effect level-1 predictors were weekend (π_2), lagged positive mood (π_3), lagged negative mood (π_4), lagged alcohol consumption (π_5), and lagged alcohol expectancy valence (π_6), which each represented the change in the log odds of drinking per 1 unit increase in the predictor. The fixed effect level-2 predictors were age (β_{01}), gender (β_{02}), alcohol drinking history (β_{03}), baseline positive-arousing alcohol expectancies (β_{04}), baseline negative-sedating alcohol expectancies (β_{05}), emotion-based rash action (β_{06}), sensation seeking (β_{07}), deficits in conscientiousness (β_{08}), religiosity (β_{09}), positive mood person-mean

(β_{010}), negative mood person-mean (β_{011}), and alcohol expectancy valence person-mean (β_{012}), which each represented the change in the log odds of drinking per 1 unit increase in the predictor. For level-2, β_{00} was the average log odds of drinking at the first time point across all participants, β_{10} was the average change in the log odds of drinking over time of day across all participants, and r_{0i} and r_{1i} were the errors associated with the intercepts and change in the log odds of drinking over time, respectively. The level-2 error terms were assumed to be normally distributed with τ_{00} representing the variance in the initial log odds of drinking, τ_{11} representing the variance in the change in the log odds of drinking over time, and τ_{10} representing the covariation between the residuals in the initial log odds of drinking and the change in the log odds of drinking over time.

The equations for the exploratory analyses were identical to the model in Appendix B, except that they included interactions between the baseline moderators and lagged expectancy valence (i.e. cross-level interactions). A separate model was created for each hypothesized baseline moderator, which resulted in 6 total models that were tested: 1 for religiosity, 2 for baseline alcohol expectancies, and 3 for baseline facets of impulsivity.

The second hypothesis (i.e. increase in positively-valenced alcohol expectancies in alcohol-related contexts) and third hypothesis regarding moderation of the second hypothesis by baseline alcohol drinking history were tested using multilevel linear regression because the outcome, alcohol expectancy valence, was treated as normally distributed. Thus, we were interested in predicting the degree of positively-valenced alcohol expectancy activation.

The equation for the multilevel linear regression of the second hypothesis was similar to the model for the main hypothesis, except that a linear mixed model was used and the outcome variable was alcohol expectancy valence for time of day t and participant i instead of alcohol consumption. A random intercept and a random effect for time of day were modeled. Fixed effect level-1 predictors included weekday, drinking status, and alcohol context. Fixed effect level-2 predictors were the same predictors from the main hypothesis, except that alcohol expectancy valence person-mean was not included due to criterion contamination (i.e. this variable is directly calculated using the scores from the outcome variable). There was also an error term at level-1 (e_{ti}) that was assumed to be distributed as $N(0, \sigma^2)$. The equation for the multilevel linear regression of the third hypothesis was identical to the model for the second hypothesis, except that it also included an interaction between baseline alcohol drinking history and alcohol context (i.e. cross-level interaction).

CHAPTER THREE:

RESULTS

Missing Data

Maximum likelihood estimation provides unbiased parameter estimates when data is missing at random, and less biased estimates than traditional techniques when data is missing not at random. Although it is impossible to completely verify whether data is missing at random or missing not at random, it is still useful to examine the data for patterns of missing data (Baraldi & Enders, 2010). After removing 5 participants for reporting average drinks per drinking occasion during the EMA protocol that were over 3 standard deviations above the mean, a total of 421 participants were left for inclusion in the analyses. Table 1 provides a cross-table of the number of participants and the number of EMA assessments that were completed. The table shows that about 50% of the 421 participants contributed 13 or more assessment time points usable for these analyses (maximum possible time points is 18). The compliance rates by time of day were as follows: 71% at 10am, 76% at 1pm, 71% at 4pm, 71% at 7pm, 74% at 10pm, and 40% at 1am. Compliance rates by day of the week (aggregating all hourly prompts within each day) were as follows: 74% on Tuesday, 67% on Friday, and 60% on Saturday. Therefore, missing data was more likely to occur at 1am and on Saturdays. To examine if missing data was related to any of the level-2 (person-level) variables, Bayesian linear models were used to directly test the evidence in favor of the null hypothesis that there is no relationship between these variables and missing data (Rouder, Speckman, Sun, Morey, & Iverson, 2009; Rouder & Morey, 2012). The total number of missing data points for each participant was used as the outcome variable. Table 2 shows the results of the Bayesian analyses for each variable. There was substantial evidence in favor of the null hypothesis for all predictor variables, except A.E. Max positive-arousing and alcohol expectancy valence person-mean (see Wetzels et al., 2011 for interpreting Bayes factors). Those two variables had equivocal evidence, meaning that the evidence was insufficient to clearly support the null or alternative hypothesis; given our relatively large sample size, the lack of strong evidence in favor of the alternative hypothesis suggests that the magnitude of any non-null effect is likely to be small. We found the same patterns of missing data when we included only data used in the main hypothesis test. Therefore, at least for the variables that we were able to test, the risk of violating the missing at random assumption for maximum likelihood estimation appears to be minimal.

Descriptives

Across all participants and time points, alcohol consumption was reported on 17% of the assessments. Most of the drinking episodes (78%) were reported on weekend days (i.e. Friday and Saturday). For time of day, 5% of drinking episodes were reported between 10am – 1pm, 8% were reported between 1pm – 4pm, 22% were reported between 4pm – 7pm, 37% were reported between 7pm – 10pm, and 28% were reported between 10pm – 1am. Table 3 shows the descriptive statistics for level-2 (person-level) continuous predictors. Table 4 shows the descriptive statistics for level-1 (hourly-level) continuous predictors. The variables generally appeared to be normally distributed. Table 5 shows the correlations between level-2 predictors;

the two A.E. Max variables were moderately and positively correlated, as were rash action and deficits in conscientiousness. All other level-2 variables had either small correlations or were not correlated. Univariate correlations between the level-1 predictors showed that lagged positive mood was negatively correlated with lagged negative mood (r = -0.40, p < .01) and positively correlated with lagged alcohol expectancy valence (r = 0.21, p < .01). Lagged negative mood was negatively correlated with lagged alcohol expectancy valence (r = -0.11, p < .01). Most participants (62%) reported drinking alcohol at least once during the study. Therefore, concerns of non-normality, multicollinearity, and sparsity of drinking events appear to be minimal.

Main Hypothesis: Expectancy Valance Predicts Future Drinking

To determine the ICC for the unconditional multilevel logistic model for alcohol consumption, we used the formula proposed by Snijders and Bosker (1999) in which a constant 3.29 is used in place of a level-1 residual variance because level-1 residual variances that are directly estimated from a multilevel logistic model are often considered to be uninformative. The analysis indicated that about 29% of the variability in alcohol consumption was due to between-person differences, and about 71% of the variability was due to within-person changes. Therefore, most of the changes in drinking were due to the state-like changes that participants experienced on an hourly or daily basis, as opposed to the more trait-like differences between participants that were constant throughout the study. This finding indicated that predictors which varied on an hourly or daily basis can potentially explain far more variance in alcohol consumption than predictors which were stable across days (e.g. demographic variables).

Table 6 shows the results of the multilevel logistic model predicting alcohol consumption. As predicted, the valence of the lagged alcohol expectancies was positively associated with alcohol consumption during the next 3 hours, after controlling for the other covariates in the model. More specifically, conversion of the log odds estimate for lagged alcohol expectancy valence to an odds ratio indicated that each 1 point increase was associated with a 12% increase in the odds of drinking alcohol during the next 3 hours. Multiplying that odds ratio with the standard deviation of the lagged alcohol expectancy valence scores (SD = 2.41) indicated that a person who was 1 standard deviation more positively valenced than their own personal average alcohol expectancy valence level had a 29% higher odds of drinking alcohol in the next 3 hours. Figure 1 shows the prospective relationship between alcohol expectancy valence and future drinking based on the results of the model. As we hypothesized, therefore, increases in positively valenced alcohol expectancies were significantly predictive of engaging in alcohol consumption in the near future above and beyond the predictive effects of other important variables.

The results of the exploratory analyses for the baseline moderators indicated that none of the interactions were significant after controlling for other important variables, $p > .05$. Therefore, we failed to find evidence that the predictive association between alcohol expectancy valence and future alcohol consumption was moderated by religiosity, explicitly measured positive expectancies, explicitly measured negative expectancies, sensation seeking, emotion-based rash action, and deficits in conscientiousness.

Secondary Hypotheses: Expectancy Valence Associated with Alcohol Context

To determine the ICC for the unconditional multilevel linear model for alcohol expectancy valence, the level-2 residual variance was divided by the total variability. The analysis indicated that about 42% of the variability in alcohol expectancy valence was due to between-person differences, and about 58% of the variability was due to within-person changes. Roughly equal amounts of the variability in in-vivo alcohol expectancy valence were due to the state-like changes that participants experienced on an hourly/daily basis and the more trait-like differences between participants that were constant throughout the study. Therefore, predictors which varied on an hourly or daily basis could potentially explain about the same amount of variance in in-vivo alcohol expectancy valence as predictors which were stable across days (e.g. demographic variables).

Contrary to hypothesis 2, the multilevel linear model predicting alcohol expectancy valence indicated that being in an alcohol-related context was not significantly related to alcohol expectancy valence, $p > .05$. Although alcohol-related contexts had more positive alcohol expectancy valence than other contexts on average (see Figure 2), this difference was not significant. Thus, we failed to find evidence that being in an alcohol-related context would be associated with more positively valenced alcohol expectancies. Contrary to hypothesis 3, the model testing the baseline moderation of the second hypothesis indicated that the interaction was not significant, $p > .05$. Therefore, we failed to find evidence that any association between alcohol-related contexts and alcohol expectancy valence was moderated by alcohol drinking history.

Table 1. *Cross-table of assessments included by number of participants.*

# of Assessments Contributed to the Analyses	# of Participants	% of Participants	Cumulative % of Participants
1	9	2%	2%
2	12	3%	5%
3	13	3%	8%
4	8	2%	10%
5	18	4%	14%
6	12	3%	17%
7	6	1%	19%
8	16	4%	22%
9	14	3%	26%
10	17	4%	30%
11	19	5%	34%
12	27	6%	41%
13	40	10%	50%
14	47	11%	61%
15	63	15%	76%
16	52	12%	89%
17	33	8%	96%
18	15	4%	100%

Note. Data from a total of 421 participants were included in these analyses. The total possible number of assessments that could be contributed was 18.

Table 2. *Bayesian linear models predicting missing data.*

Level-2 Predictors	Bayes $Factor_{10}$
Age	0.18 [a]
Gender	0.23 [a]
A.E. Max positive-arousing	**0.62 [b]**
A.E. Max negative-sedating	0.20 [a]
SUPPS-P rash action	0.24 [a]
SUPPS-P sensation seeking	0.12 [a]
SUPPS-P deficits in conscientiousness	0.13 [a]
Religiosity	0.11 [a]
Alcohol drinking history	0.17 [a]
Negative mood person-mean	0.12 [a]
Positive mood person-mean	0.15 [a]
Alcohol expectancy valence person-mean	**0.41 [b]**

Note. Separate Bayesian linear regressions for each variable as a predictor of missing data were conducted. The *BayesFactor* package in R was used for analyses. Prior *r* scale of 0.5 was used for the *g* priors in the models.

[a] = Substantial evidence for the null hypothesis.

[b] = Equivocal evidence.

Table 3. *Descriptive statistics of level-2 (person-level; time invariant) continuous predictors.*

Level-2 Predictors[a]	*N*[b]	*Mean*	*SD*	*Skew*	*Kurtosis*
A.E. Max positive-arousing	419	3.45	0.97	-0.46	0.73
A.E. Max negative-sedating	418	2.80	0.96	-0.31	-0.12
SUPPS-P rash action	417	2.03	0.60	0.36	-0.11
SUPPS-P sensation seeking	417	2.81	0.66	-0.30	-0.20
SUPPS-P deficits in conscientiousness	417	1.72	0.43	0.38	-0.05
Religiosity	418	2.46	1.26	0.48	-0.94
Alcohol drinking history	379	0.81	0.72	1.81	3.83
Negative mood person-mean	421	1.02	0.90	1.27	1.86
Positive mood person-mean	421	2.17	1.03	0.21	-0.55
Alcohol expectancy valence person-mean	421	0.38	2.34	-0.06	-0.12

Note. [a] These descriptives are from the raw, non-centered scores. [b]Although the total *N* was 421, a few participants had missing baseline data. *N* = number of participants; *SD* = standard deviation.

Table 4. *Descriptive statistics of level-1 (hourly-level; time varying) continuous predictors.*

Level-1 Predictors[a]	*N*	*Mean*	*SD*	*Skew*	*Kurtosis*
Lagged negative mood	3505	0.01	0.74	0.97	3.03
Lagged positive mood	3505	0.02	1.01	0.14	0.63
Lagged alcohol expectancy valence	3518	0.09	2.41	-0.09	0.43

Note. [a] These descriptives are from the person-centered scores. "Lagged" means that the scores from the previous time point (3 hours before) were matched to alcohol consumption at the next time point. *N* = number of observations; *SD* = standard deviation.

Table 5. *Correlations between level-2 (person-level; time invariant) predictors.*

Level-2 Predictors	1	2	3	4	5	6	7	8	9	10
1. Negative mood person-mean										
2. Positive mood person-mean	-0.07									
3. Alcohol expectancy valence person-mean	-0.02	0.15*								
4. Age	-0.12*	-0.09	-0.02							
5. Drinks per day (30 days)	0.06	0.13	0.21*	-0.02						
6. A.E. Max positive-arousing	0.08	0.13	0.11	-0.06	0.17*					
7. A.E. Max negative-sedating	0.08	-0.12	-0.26*	0.00	-0.11	0.34*				
8. SUPPS-P rash action	0.25*	-0.04	0.04	-0.02	0.18*	0.16*	0.06			
9. SUPPS-P sensation seeking	-0.08	0.13*	0.02	-0.04	0.04	0.06	-0.01	0.14		
10. SUPPS-P deficits in conscientiousness	0.06	-0.11*	0.06	-0.08	0.12	-0.05	-0.05	0.35*	-0.08	
11. Religiosity	-0.01	0.03	0.06	-0.03	-0.12	0.04	0.01	-0.02	-0.05	-0.03

Note. * $p < .01$.

Table 6. *Logistic multilevel model predicting alcohol consumption.*

Parameters	Parameter Estimates
Fixed Effects Predictors	
Intercept (β_{00})	-5.50 (0.41)*
Time of day (β_{10})	0.70 (0.08)*
Weekend (π_2)	1.08 (0.15)*
Lagged positive mood (π_3)	0.26 (0.07)*
Lagged negative mood (π_4)	0.03 (0.10)
Lagged alcohol consumption (π_5)	2.32 (0.22)*
Lagged alcohol expectancy valence (π_6)	0.11 (0.03)*
Age (β_{01})	0.05 (0.02)*
Gender (β_{02})	0.46 (0.20)*
Alcohol drinking history (β_{03})	0.40 (0.12)*
Positive-arousing alcohol expectancy (β_{04})	0.08 (0.10)
Negative-sedating alcohol expectancy (β_{05})	0.13 (0.10)
Emotion-based rash action (β_{06})	0.13 (0.16)
Sensation seeking (β_{07})	-0.19 (0.13)
Deficits in conscientiousness (β_{08})	0.12 (0.21)
Religiosity (β_{09})	-0.06 (0.07)
Positive mood person-mean (β_{010})	0.01 (0.09)
Negative mood person-mean (β_{011})	-0.27 (0.11)*
Alcohol expectancy valence person-mean (β_{012})	0.19 (0.04)*
Variance Estimates	
Level-2 intercept variance (τ_{00})	1.69 (0.89)*
Level-2 slope variance (τ_{11})	0.09 (0.07)
Level-2 intercept-slope covariance (τ_{10})	-0.29 (0.21)

Note. Parameter estimates are log odds. Alcohol consumption is binary: 0 = no drinking, 1 = any drinking. Time of day is centered so that 0 corresponds to 10am. Weekend is coded so that 0 is Tuesday and 1 is Friday and Saturday. Age is centered so that 0 is 18 years-old. Lagged moods and expectancy valence are person-mean centered. Baseline variables are grand-mean centered. Empirical standard errors (SE) follow parameter estimates in parentheses. β's are level-2 predictors and π's are level-1 predictors. "Lagged" means that the scores from the previous time point (3 hours before) were matched to alcohol consumption at the next time point. * $p < .05$.

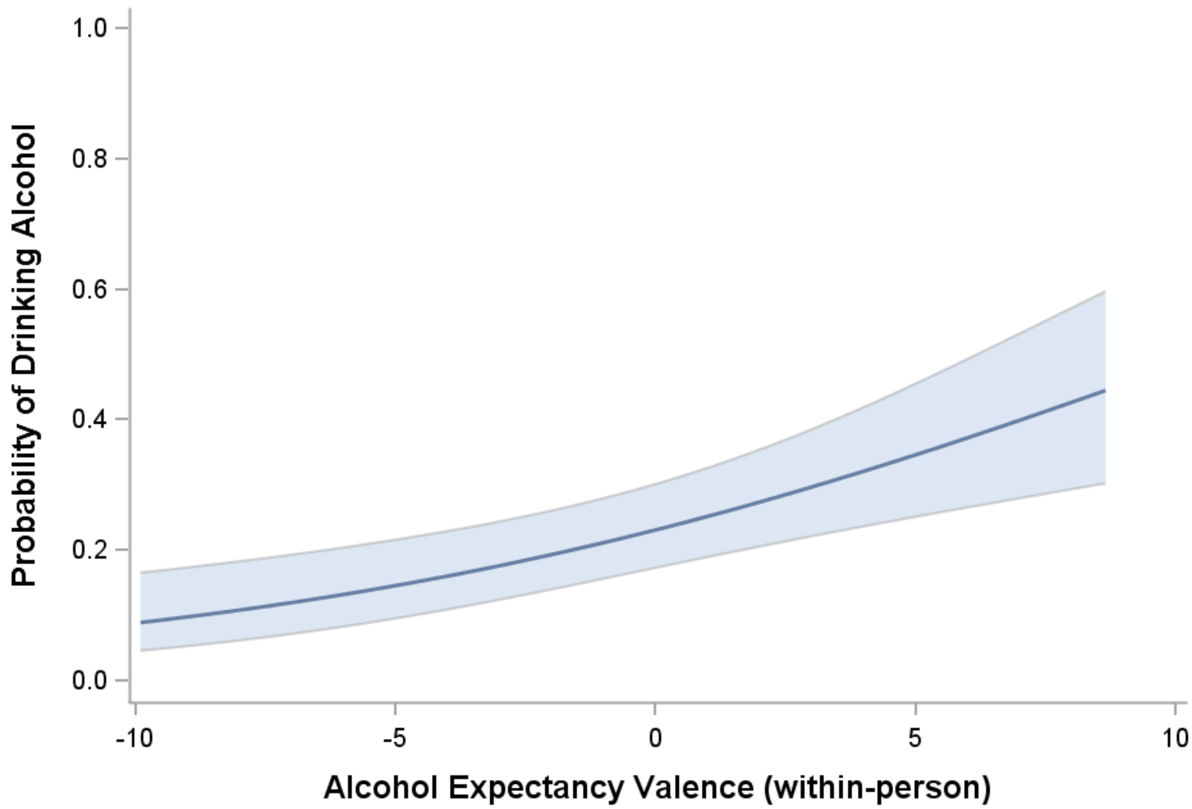

Figure 1. Probability of drinking alcohol during the next 3 hours by expectancy valence.
Notes. The predicted probabilities of drinking alcohol during the next 3 hours by alcohol expectancy valence, based on the results of the logistic multilevel model. Shaded area represents the 95% confidence interval. The figure represents predicted probabilities for a 21 year old male at 7pm on the weekend who consumed an average amount of alcohol in the past 30 days, is experiencing an average positive and negative mood relative to himself, has not consumed any alcohol in the past 3 hours, and has average trait levels of alcohol expectancy, impulsivity, positive mood, negative mood, and religiosity relative to other participants in the sample. “Average” refers to grand-means and person-means.

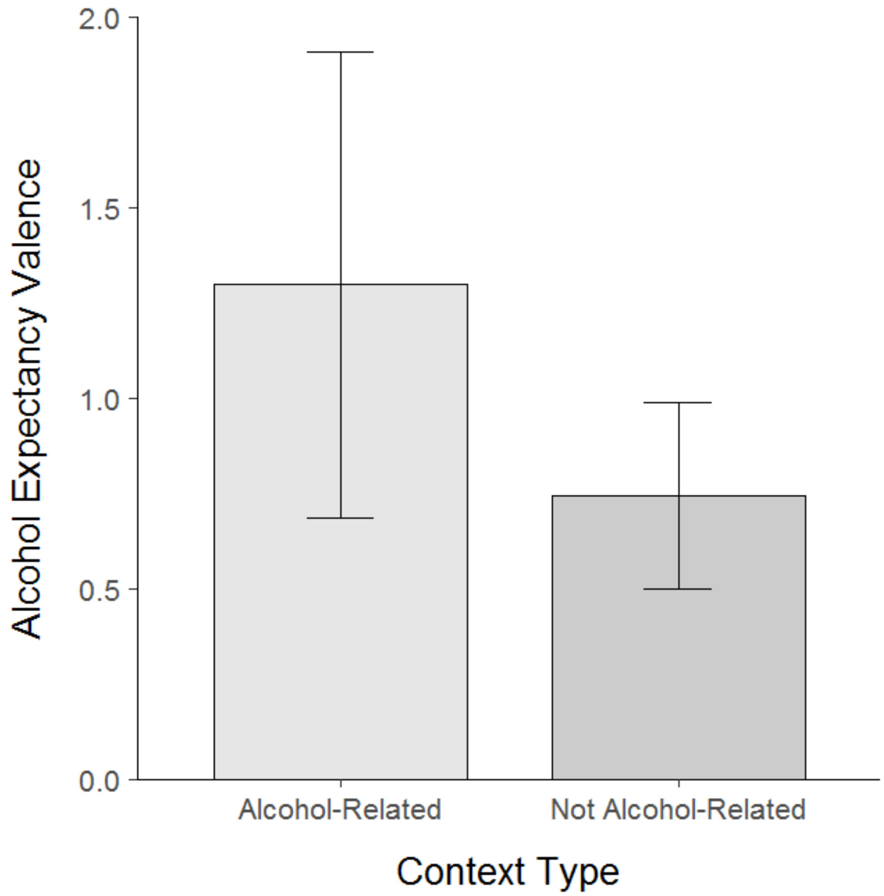

Figure 2. Alcohol expectancy valence by alcohol context type.
Notes. Predicted alcohol expectancy valence means and 95% confidence intervals, after controlling for other covariates and based on the results of the multilevel linear model. Although alcohol expectancy valence was more positive in alcohol-related contexts, this difference was not significant ($p > .05$)

CHAPTER FOUR:

DISCUSSION

Our findings supported the main hypothesis that fluctuations in alcohol expectancies would reliably predict alcohol consumption in the next few hours. This association remained present even after accounting for important variables that fluctuate within a day (e.g. positive and negative mood) and trait-like characteristics of the participants (e.g. questionnaire-based impulsivity and alcohol expectancies, alcohol drinking history, gender) that have been previously shown to predict future alcohol consumption. By applying a “contextual effects” model, we also controlled for each participant’s average mood and alcohol expectancy valence throughout the entire study. After accounting for many alcohol-related covariates, an increase of more positively valenced alcohol expectancies, relative to one’s own average expectancy level, reliably increased the odds of drinking alcohol during the next few hours. These results support the consideration of expectancy processes as part of the larger motivational system that is theorized to generate alcohol consumption. Further, these results reveal that expectancy processes may include a dynamic element (i.e. they can change rapidly in real-time and are not merely static indicators) that can be distinguished from general affective traits and states, which are also likely causal mechanisms that guide future behaviors.

A number of features in our study also provide evidence for a causal motivational link between positively valenced alcohol expectancies and alcohol consumption. Although the concept of causation and how to establish causal claims is a hotly contested topic (e.g. Pearl, 2010), medical and social scientists have traditionally used criteria such as strength of association, temporal sequence, and experimental manipulation when evaluating causal claims in research (e.g. Hill, 1965). In our particular study, some of the criteria for causal claims were established by the use of time-lags and within-person centering to restructure our data and recode the alcohol expectancy valence scores. Pairing the alcohol expectancy valence scores observed at each time point to the drinking status of the individual during the next 3 hours helped to establish the temporal precedence of changes in alcohol expectancy valence occurring prior to alcohol consumption. Within-person centering of the alcohol expectancy valence scores helped to establish that the prediction of future alcohol consumption was due to within-person changes in the anticipatory motivational system and not merely between-person differences. That these findings represented within-person changes in alcohol expectancy valence above and beyond between-person differences was also supported by the use of 2 different between-person measures of alcohol expectancy valence as covariates: the alcohol expectancy valence person-means from the EMA portion of the study and the A.E. Max factors obtained at baseline. Other plausible third variable explanations of the association between in-vivo alcohol expectancy valence and future drinking were included as covariates. Including drinking status at the previous time point and baseline alcohol drinking history as covariates suggest that our findings should not be explained away as merely “A predicts A” or “behavior predicts behavior”. Time of day and weekend status were included as covariates because they are useful proxies for environmental and social contingencies that have been linked with alcohol consumption (e.g. sleep-wake cycles, school/work schedules, hanging out with friends). We also accounted for participants' average mood levels during the study and recent deviations from those average mood levels, which suggests that the alcohol expectancy valence measure is more than just a proxy for general mood states. In this way, the structuring of the data to ensure temporal precedence and the inclusion of many plausible third variables as covariates strengthens the case for a causal link between positively valenced alcohol expectancies and alcohol consumption assessed in-vivo.

These findings build on and advance previous research in a number of ways. While many studies have already shown that alcohol expectancies predict alcohol consumption in the long-term (e.g. months, years) and that manipulating expectancies in the laboratory influences alcohol consumption, we have now provided evidence for alcohol expectancies predicting future alcohol consumption in the short-term (i.e. hourly, within the same day) and outside of the laboratory while people are living their everyday lives. As a consequence, we may infer that alcohol expectancies can be dynamic and fluctuate during the course of a day, and that these fluctuations can be systematically linked to future alcohol consumption in that same day. More broadly, the findings lend further support to the notion that expectancies are a key part of the anticipatory motivational system that guides behavior. As the anticipation of a stimulus or activity becomes more positively valenced and rewarding, future behaviors will become more energized towards pursuing that stimulus or activity (i.e. increased motivational direction and vigor; Simpson & Balsam, 2015). If expectancies do indeed play a key role in motivating future behaviors, then these findings also support the inclusion of the expectancy concept in many of the major theories of addiction because these theories emphasize the identification and description of motivational mechanisms for compulsive drug use (Volkow, Koob, & McClellan, 2016; Meyer, King, &

Ferrario, 2015; Robinson & Berridge, 2003; Everitt & Robbins, 2005; Moss & Albery, 2009; Wiers et al., 2007).

Other advances of our study include methodological techniques for probing the anticipatory motivational system in-vivo using implicit probes. To our knowledge, no other studies have measured drug related free associates multiple times within a single day and outside of the laboratory. Further, to our knowledge, no other studies have weighted drug related free associates using a salience index that accounts for the list length and ranks of the free associates within the list. Giving more weight to the first free associate responses is important because the first words mentioned on an open-ended list represent the most salient concepts in mind at that moment and the first words mentioned are more reliable indicators of the relative strength in memory between the concept represented by the free associate prompt and the concepts represented by the free associate responses. Although we did not find evidence of alcohol free associates being linked to alcohol-related contexts, our findings did link alcohol free associates to prospective alcohol consumption. Given the many theoretical advantages of free associates discussed previously (see Methods section), it appears that using a free association task as part of an EMA procedure can be an effective and time-efficient method for probing in-vivo implicit memory network activation that is related to the motivational pathways that guide future behavior.

Our study's failure to find evidence of an association between alcohol free associate valence and alcohol-related contexts is somewhat surprising and notable, given that plenty of previous research supported an association between them. Although it is possible that no link can be found between alcohol expectancies and alcohol-related contexts outside the laboratory, it is likely that the method we used to measure environmental context did not have enough precision for a proper test of our second hypothesis. In order to maximize compliance and keep participant burden to a minimum, we purposefully measured environmental context using an open-ended prompt, which can allow for both very detailed and very broad responses. In doing so, however, the variable we created to represent alcohol-related vs. non-alcohol-related contexts may have been too imprecise. For instance, participants who were either hosts or guests at house parties may have answered the prompt with “at home” or “at a friend’s house”, rather than “at a party”, which would change their categorization on the alcohol-related context variable. Since most participants were under the legal drinking age, it seems likely that much of their drinking would occur in non-regulated locations, such as homes, rather than at more regulated establishments, such as bars or clubs, which may have resulted in many inaccurate categorizations on the context variable. Inaccurate categorizations on the context variable would lead to unreliable estimates of the association between alcohol expectancies and alcohol-related contexts; this may be evidenced by the relatively low number of time points that were categorized as ‘alcohol-related’ (2.4%). The low number of contexts categorized as ‘alcohol-related’ also led to larger error margins and less power, which can be seen in Figure 2. These difficulties in accurately classifying alcohol-related contexts may also explain why we failed to find evidence for the baseline moderation of any relationship between alcohol expectancies and alcohol-related contexts. Future studies could improve the test for a relationship between alcohol expectancies and alcohol-related contexts by having more standardized and/or close-ended questions that may more precisely assess environmental context.

We also did not find evidence for baseline moderation of the relationship between alcohol expectancies and alcohol consumption. However, since no other studies have examined the covariation between alcohol expectancies and future alcohol consumption in-vivo using an EMA procedure, our hypotheses regarding baseline moderation of any such covariation were largely exploratory. And so, these null findings for baseline moderation should be considered preliminary.

One possible limitation to our study is related to how we scored free associates. Scoring free associate responses can be challenging and requires careful deliberation of the pros and cons of whatever scoring method is chosen. To efficiently maximize the number of free associates scored in this study, we took advantage of previously collected valence ratings of free associates from a different sample of college students. However, it is not guaranteed that the valence ratings from that college student sample would be identical to the college students in the current sample had we collected those ratings from this sample. Relatedly, imputing valence scores that are averages of an entire student sample presumes that all students would rate the free associate words similarly, which is an assumption that previous research would not support (Reich et al., 2012). Besides any between-person differences, the valence of any given free associate word might change within-persons and be temporally contingent; for example, the same person might rate the valence of “drunk” as having different valence scores at 10am, 7pm, and 1am. Nonetheless, the internal reliability of the valence ratings in this sample was good, especially given that many other implicit measures of cognition tend to have questionable reliability (Reich et al., 2010). Other possible limitations include the lack of experimental manipulation and the generalizability of our findings to other contexts and/or populations. Causal inference is most strongly based upon experimental manipulation, and we did not experimentally manipulate alcohol expectancy valence. Although we controlled for many plausible third variables, there may be other unaccounted for third variables that can explain the observed relationship between alcohol expectancy valence and alcohol consumption. The generalizability of our findings is limited to a college student sample, which can be problematic for inferring to most other human populations (Henrich, Heine, & Norenzayan, 2010). It is also unknown whether collecting the same data during holidays, large sporting event days, or other days that have been shown to have atypical alcohol consumption levels would produce different results, since we purposely avoided collecting data on such days.

Another limitation was to specifically ask for alcohol consumption in the past 3 hours during the EMA portion of the study. If a participant completed consecutive surveys either too close or too far in time from each other, it is possible that participants who interpreted the prompt very literally will either double count the number of drinks they've had or may not report drinking that has occurred. An alternative phrasing that may seem, at first, to improve our question would be to have asked about drinking "…since the last time you completed the previous survey" instead of "… in the past 3 hours." However, this alternative phrasing assumes that a participant completes all the surveys (a highly unrealistic assumption); if a participant fails to complete a preceding survey(s), that participant may then count all drinks consumed over the past 6 (or 9 or 12) hours, instead of 3 hours. The resulting variability in time spans would make it difficult to interpret this variable and threatens the validity of our method for measuring the buildup of positive alcohol expectancy valence proximal to drinking. Similarly, although dichotomizing the drink counts begs the question of why we did not simply ask a dichotomous alcohol question, we preferred to obtain more detailed alcohol consumption information that may be useful for further exploratory analyses; the benefit of having richer drinking data that could be transformed into a dichotomous variable outweighed the cost of minimally increasing participant burden by asking for the number of specific drinks. Therefore, despite the possible contamination of specifically asking for alcohol consumption in the past 3 hours and dichotomizing the drinking, dichotomous alcohol consumption in the past 3-hours was used as the primary measure of in-vivo alcohol consumption.

Our findings provide solid groundwork for future research. An extension of this study that would improve the argument that alcohol expectancies cause changes in drinking status in-vivo is to experimentally manipulate expectancies in-vivo and see whether there is a resulting change in drinking levels. One way to manipulate expectancies would be to create a brief expectancy challenge intervention that could be delivered using ecological momentary intervention procedures, which are identical to EMA procedures but with the added complexity of determining when is the best moment to deliver the intervention (EMI; Beckjord & Shiffman, 2007). Identifying when the anticipatory motivational system is building up in preparation for alcohol consumption and then delivering a "just-in-time" challenge to the motivational system in order to sway alcohol consumption in the near future would be a stronger test for the causal relationship that our findings currently suggest. Other studies may focus on optimizing the assessment of alcohol expectancies in-vivo. Although we demonstrated the utility of free association for in-vivo assessments in this study, future studies may examine other methods for assessing alcohol expectancies, whether they be more explicit (e.g. abbreviated versions of traditional expectancy questionnaires) or more implicit (e.g. stroop tasks; implicit association tests). It would be critical for those studies to determine how much true score variability in alcohol expectancies such methods are able to capture, since it may difficult, particularly for the more explicit questionnaire-based measures, to identify subtle changes in alcohol expectancies throughout the day. Another follow-up to our study would be to assess if fluctuations in alcohol expectancies predict quantity of alcohol consumption, instead of just predicting whether drinking occurred or not. Finally, testing whether our results generalize to people from other cultural backgrounds would also be particularly useful, since it is possible that different patterns of association between alcohol expectancies and drinking will emerge (e.g. Mahoney et al., 2011).

The theoretical and empirical foundation of this study suggested that expectancies are part of dynamic motivational processes that guide daily behavior, and thus would guide future behavior even within the span of a few hours. Our findings within the alcohol domain build on that foundation by providing evidence that such processes can be probed in real-time using well-established measures of implicit cognition, and that those processes are indeed predictive of behaviors in the near future.

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APPENDIX A:

SALIENCE INDEX

The Smith's salience (*S*) index for each free associate word produced by each participant can be calculated by taking the total number of free associate words a participant mentioned at a given time point, subtracting the position/rank of the particular word, adding 1, and then dividing that value by the total number of free associate words for that participant at that time (Sutrop, 2001). For example, a participant might give the following 3 free associates in order at 8pm: tired, relaxed, sick. The *S* index for 'tired' would be (3 – 1 + 1) / 3 = 1.0; the *S* index for 'relaxed' would be (3 – 2 + 1) / 3 = .67; and the *S* index for 'sick' would be (3 – 3 + 1) / 3 = .33. To find an aggregate *S* index for a particular word for a group of *N* participants, we could simply take the average of the group's *S* index scores for the particular word (i.e. $\Sigma(S \text{ index}) / N$). Values for the aggregated *S* index can range between 0 and 1, with a score of 1 indicating that a word was listed as the first free associate by every participant and 0 indicating that a word was never listed as a free associate by any participant. Thus, this index can be considered a measure of how salient words/concepts are when using a free-listing task, such as free association word lists (Smith, 1993; Thompson & Juan, 2006).

APPENDIX B:

MULTILEVEL EQUATIONS

The equation for the multilevel logistic regression model for the main hypothesis is as follows:

Level-1 equation

Drinking$_{ti}$ = π_{0i} + π_{1i} Time$_{ti}$ + π_2 Weekend$_{ti}$ + π_3 Lagged positive mood$_{ti}$ +

π_4 Lagged negative mood$_{ti}$ + π_5 Lagged alcohol consumption$_{ti}$ +

π_6 Lagged alcohol expectancy valence$_{ti}$

Level-2 equations

π_{0i} = β_{00} + β_{01} Age$_i$ + β_{02} Gender$_i$ + β_{03} Alcohol drinking history$_i$ +

β_{04} Positive-arousing alcohol expectancy$_i$ + β_{05} Negative-sedating alcohol expectancy$_i$ +

β_{06} Emotion-based rash action$_i$ + β_{07} Sensation seeking$_i$ +

β_{08} Deficits in conscientiousness$_i$ + β_{09} Religiosity$_i$ + β_{010} Positive mood person-mean$_i$ +

β_{011} Negative mood person-mean$_i$ + β_{012} Alcohol expectancy valence person-mean$_i$ + r_{0i}

$\pi_{1i} = \beta_{10} + r_{1i}$

APPENDIX C:

IRB APPROVAL LETTER

UNIVERSITY OF SOUTH FLORIDA

RESEARCH INTEGRITY AND COMPLIANCE
Institutional Review Boards, FWA No. 00001669
12901 Bruce B. Downs Blvd., MDC035 • Tampa, FL 33612-4799
(813) 974-5638 • FAX (813) 974-7091

August 16, 2016

Bryan Benitez
Psychology
Tampa, FL
33613

RE:	**Expedited Approval for Initial Review**
IRB#:	Pro00027449
Title:	Anticipatory Motivation for Drinking Alcohol: An In-Vivo Study

Study Approval Period: 8/16/2016 to 8/16/2017

Dear Mr. Benitez:

On 8/16/2016, the Institutional Review Board (IRB) reviewed and **APPROVED** the above application and all documents contained within, including those outlined below.

Approved Item(s):

Protocol Document(s):

Benitez IRB protocol version 1 (8-10-16).docx

Consent/Assent Document(s)*:

Thesis Online Consent form.docx (granted a waiver)

*Please use only the official IRB stamped informed consent/assent document(s) found under the "Attachments" tab. Please note, these consent/assent document(s) are only valid during the approval period indicated at the top of the form(s). Consents granted a waiver are not stamped.

It was the determination of the IRB that your study qualified for expedited review which includes activities that (1) present no more than minimal risk to human subjects, and (2) involve only procedures listed in one or more of the categories outlined below. The IRB may review research through the expedited review procedure authorized by 45CFR46.110. The research proposed in this study is categorized under the following expedited review category:

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Your study qualifies for a waiver of the requirements for the documentation of informed consent as outlined in the federal regulations at 45CFR46.117(c) which states that an IRB may waive the requirement for the investigator to obtain a signed consent form for some or all subjects if it finds either: (1) That the only record linking the subject and the research would be the consent document and the principal risk would be potential harm resulting from a breach of confidentiality. Each subject will be asked whether the subject wants documentation linking the subject with the research, and the subject's wishes will govern; or (2) That the research presents no more than minimal risk of harm to subjects and involves no procedures for which written consent is normally required outside of the research context. (Online Consent form).

As the principal investigator of this study, it is your responsibility to conduct this study in accordance with IRB policies and procedures and as approved by the IRB. Any changes to the approved research must be submitted to the IRB for review and approval via an amendment. Additionally, all unanticipated problems must be reported to the USF IRB within five (5) calendar days.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

Kristen Salomon, Ph.D., Vice Chairperson
USF Institutional Review Board