

A MULTI-METHOD ANALYSIS OF THE ACQUIRED PREPAREDNESS MODEL
OF RISK FOR ALCOHOL PROBLEMS

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OF RISK FOR ALCOHOL PROBLEMS

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ABSTRACT

The acquired preparedness model (APM) integrates both general risk factors and alcohol-related cognitive factors to understand the development of alcohol use and its associated problems. The present project utilized an innovative multi-method approach (self-report questionnaires and event-related potential [ERP] techniques) to conduct a more comprehensive and in-depth analysis of the APM. Participants were 137 young adult ($M = 22$ years old, $SD = 3$, 59% female) social drinkers recruited from a Midwest college town. Self-report measures assessed reward sensitivity (general risk factor) and alcohol outcome expectancies (cognitive factor). The P3 component of the ERP was recorded while participants responded to infrequent normal- and rotated-head oddball targets (general risk factor) and while they viewed infrequent, alcohol cues (cognitive factor). Consistent with previous research, results indicated a significant indirect path from reward hypersensitivity to drinking frequency through more positive expectancies about alcohol's effects. Positive alcohol expectancies were also found to mediate the influence of reward hypersensitivity on substance use problems, suggesting that the acquisition of more positive alcohol expectancies may reflect the formation of more positive drug-related expectancies. A significant mediation effect for negative expectancies on the association between reward hypersensitivity and alcohol-related problems was observed. Common method variance had a marked impact on the results of mediation analyses for involving the P3 component. These findings point to the importance of accounting for method effects to reduce the likelihood of spurious results and misspecification of theoretical models.

INTRODUCTION

Risk factors for alcohol use, problems, and disorders can be divided into two categories: general, non-specific risk factors that increase the likelihood of a range of externalizing behaviors, and risk factors that are specific to alcohol (Smith & Anderson, 2001). Studies have identified a large number of general risk factors for problematic use, including personality characteristics, genetic and intergenerational risk, and neurophysiological markers (Agrawal & Lynskey, 2008; Carlson, Iacono, & McGue, 2002; Justus, Finn, & Steinmetz, 2001; Lejuez et al., 2010; Sher & Trull, 1994). These general risk factors are associated with a number of disorders and behaviors, are not specific to alcohol problems (see Iacono, Malone, & McGue, 2008), and provide little information on why some individuals with high levels of these risk factor develop alcohol problems whereas others do not. Psychosocial learning models of alcohol use, on the other hand, provide this desired specificity—they postulate that drinking behaviors derive from vicarious and direct experience with the reinforcing effects of drinking (Goldman, Del Boca, & Darkes, 1999; Goldman, Reich, & Darkes, 2006). This learning process results in the formation of alcohol-related cognitions (e.g., expectancies, motives), which in turn influence future drinking behaviors. However, substance-related learning is unlikely to be based exclusively on vicarious and direct experiences, as individuals have been shown to form different associations from the same experience (Smith, Williams, Cyders, & Kelley, 2006). Theorists have recognized that individual difference factors that are present from early life can shape what people learn from their environment (Caspi & Moffitt, 1993; Caspi & Roberts, 2001). Thus, these general risk factors can influence learning, and in turn learning influences behavior.

The Acquired Preparedness Model

Based on this notion, Smith and colleagues (McCarthy, Kroll, & Smith, 2001a; McCarthy, Miller, Smith, & Smith, 2001b; Smith & Anderson, 2001) developed the Acquired Preparedness Model (APM) of alcohol use, which integrates both general risk factors and alcohol-related cognitions that derive from past learning experiences with alcohol. In this model, behavioral disinhibition is identified as one general risk factor that likely contributes to the formation of alcohol-related learning and, in turn, alcohol involvement. Trait disinhibition has been theorized to be the mechanism that underlies rash, impulsive behaviors (Patterson & Newman, 1993) and represents a general predisposition to externalizing disorders (Krueger et al., 2002). While behavioral disinhibition is a defining feature of externalizing conditions, there are several mechanisms by which this trait may arise (Newman & Wallace, 1993).

Gray (1987) has proposed that characteristic traits of individuals (such as disinhibition) are shaped by two underlying brain-behavior systems: behavioral activation system (BAS) and behavioral inhibition system (BIS). The BAS is purported to respond to cues of reward and non-punishment and promotes approach behavior. The BIS, on the other hand, is purported to respond to cues of punishment and frustrative non-reward and promotes the inhibition of on-going behavior. According to Newman and Wallace (1993), one mechanism by which behavioral disinhibition may arise is by over-activation of the BAS. The over-activation of this system is thought to result in greater reward sensitivity, as indicated by an attentional bias toward reward cues (Àvila & Parcet, 2002), and a greater propensity for approach behavior (Patterson & Newman, 1993). Furthermore, prior studies have reported that this attentional bias results in a failure to attend to potential punishments, as reflected by deficits in passive avoidance learning (Newman, Patterson, Howland, &

Nichols, 1990; Patterson, Kosson, & Newman, 1987). Thus, rather than stopping and reflecting on the punishment of a behavior, individuals who are hypersensitive to rewards (ostensibly due to an overactive BAS) tend to continue to engage in reward-driven behavior (Giancola, Peterson, & Pihl, 1993; Newman, Patterson, & Kosson, 1987; Séguin, Arseneault, Boulerice, Harden, & Tremblay, 2002).

Alcohol outcome expectancies are one operationalization of alcohol-related learning that describe the particular outcomes an individual anticipates after drinking alcohol (Goldman et al., 2006). The expectancies that one holds about the outcomes of drinking are considered to be a strong motivator for the approach and/or avoidance of alcohol, such that positive expectancies promote alcohol use and negative expectancies promote abstinence (for a review, see Jones, Corbin, & Fromme, 2001). Studies have reported that children as young as 6 years old have already formed positive and negative expectancies about alcohol (Dunn & Goldman, 1998; Miller, Smith, & Goldman, 1990). Positive alcohol expectancies include expectancies that alcohol leads to social facilitation, increased sexual attractiveness, and/or alleviation of negative mood (Brown, Christiansen, & Goldman, 1987). These positive expectancies are of particular importance, as they have been found to predict drinking prospectively, to predict earlier onset of problem drinking, and to change based on drinking experience (Aas, Klepp, Laberg, & Aarø, 1995; Jester et al., 2015; Sher, Wood, Wood, & Raskin, 1996; Smith, Goldman, Greenbaum, & Christiansen, 1995). Negative expectancies include expectancies that alcohol leads to cognitive and behavioral impairment, increases aggressiveness, and promotes risky behaviors (Fromme, Stroot, & Kaplan, 1993). Some studies have found the greater negative expectancies are associated with lower levels of drinking (Leigh & Stacy, 1993; McMahon,

Jones, & O'Donnell, 1994; but see Jones et al., 2001). Conceptually, alcohol outcome expectancies are thought to function as a common final pathway by which general risk factors converge to influence alcohol use and related problems (Darkes, Greenbaum, & Goldman, 2004a; Goldman, 1999).

Empirical Tests of the Acquired Preparedness Model

According to the APM, individuals more sensitive to reward (and thus higher in trait disinhibition) are prone to form more positive expectancies about the outcomes of alcohol consumption. In support of this model, studies have consistently reported a strong relation between behavioral disinhibition, alcohol-related cognitive factors, and excessive drinking (e.g., Corbin, Iwamoto, & Fromme, 2011; Lopez-Vergara et al., 2012; McCarthy et al., 2001a, b; Wardell, Read, Colder, & Merrill, 2012). For instance, in two separate studies, McCarthy and colleagues (2001a, b) found that college students who scored higher on behavioral disinhibition also reported more positive expectancies for alcohol. These more positive expectancies, in turn, mediated the association between behavioral disinhibition and drinking (McCarthy et al., 2001a, b). In a recent longitudinal study, Wardell and colleagues (2012) supported the proposed temporal order of the APM by demonstrating that greater reward sensitivity facilitated the subsequent formation of more positive alcohol expectancies, and that these more positive expectancies predicted greater alcohol consumption at a later time point. Lopez-Vergara and colleagues (2012) replicated these findings in a prospective design that included early adolescents drawn from a large community sample. Researchers have also applied the APM to other problematic behaviors and psychological conditions, including disordered eating (e.g., Combs, Smith, Flory, Simmons, & Hill, 2010; Fischer, Settles, Collins, Gunn, & Smith, 2012), marijuana use

(e.g., Hayaki et al., 2011; Vangsness, Bry, & LaBouvie, 2005), and tobacco use (e.g., Combs, Spillane, Caudill, Stark, & Smith, 2012; Doran et al., 2013). However, a limitation of these prior studies is that they have relied predominantly on self-report questionnaires as their method of assessment. As a result, it is unclear to what extent prior findings are attributable to true associations and to what extent they are attributable to common method variance (Campbell & Fiske, 1959; Podsakoff, MacKenzie, Lee, & Podsakoff, 2003).

The Present Project

To address this issue, the present project utilized an innovative multi-method approach to partition observed variables into that due to method variance and that due to the constructs of interest, thereby permitting a finer, more comprehensive analysis of the tenets of the APM. Both self-report questionnaires and the P3 component of the event-related potential (ERP) were employed to assess general risk factors and cognitive factors related to alcohol problems. The P3 component of the ERP is a positive voltage deflection in the electroencephalogram (EEG) that develops when a person is asked to respond to an attended target stimulus in a visual or auditory oddball paradigm. This positive voltage deflection typically occurs 300-800 ms following the presentation of the target stimulus. We chose to utilize this ERP component as individual differences in P3 response elicited by neutral and alcohol-related visual targets have been linked to alcohol problems (and other externalizing conditions), trait disinhibition, and alcohol-related cognitive factors (Fishman, Goldman, & Donchin, 2008; Iacono et al., 2003; Bartholow, Henry, & Lust, 2007; Bartholow, Lust, & Tragesser, 2010).

Substantial empirical support has accumulated suggesting that P3 amplitude reduction (P3-AR) elicited by the rotated-heads oddball targets (R-HOT; Begleiter,

Porjesz, Bihari, & Kissin, 1984) is associated with increased vulnerability for developing alcohol use problems and other conditions characterized by diminished behavioral control (for a review, see Iacono et al., 2003). Additionally, P3-AR in response to R-HOT has been observed in alcoholics (Cohen, Ji, Chorlian, Begleiter, & Porjesz, 2002; Polich, Pollock, & Bloom, 1994; Prabhu et al., 2001), illicit substance abusers (Bauer, 2001), and heavy smokers (Anokhin et al., 2001). This neurophysiological marker has also been reported in health individuals who are first-degree offspring of alcoholics (for a review, see Polich & Kok, 1995) and substance abusers (Brigham, Moss, Murrelle, Kirisci, & Spinelli, 1997; Holguin, Porjesz, Chorlian, Polich, & Begleiter, 1999). Research has also linked a P3-AR to R-HOT with disinhibitory conditions that co-occur with alcohol and substance use disorders, such as conduct disorder (Bauer & Hesselbrock, 1999), attention deficit hyperactivity disorder (ADHD; Brandeis, van Leeuwen, Steger, Imhof, & Steinhausen, 2002), and adult antisocial behavior (Bauer, O'Connor, & Hesselbrock, 1994; Costa et al., 2000; Gao & Raine, 2009).

Of note, not all oddball tasks evoke the same response, so it is important to consider the nature of the tasks used to elicit P3 response in studies of different psychiatric conditions. In alcohol and substance use research, P3-AR is customarily elicited by infrequent neutral (non-arousing and low motivational salience) visual, as opposed to auditory, stimuli (Iacono, Carlson, Malone, & McGue, 2002; Iacono, Malone, & McGue, 2003). In alcohol studies using auditory tasks, P3 responses are more variable (Hill et al., 1999) and weaker (Polich & Bloom, 1999; Polich et al., 1994) than that found in studies using visual tasks. Furthermore, other psychiatric conditions, such as schizophrenia and affective disorders, have been associated with P3 amplitude reduction with auditory, not

visual tasks (Ford, 1999; Mathalon, Ford, & Pfefferbaum, 2000). Thus, it appears that visually evoked P3-AR serves as a general risk factor for externalizing conditions, whereas auditory evoked P3-AR is a risk factor for other psychiatric conditions (Iacono et al., 2003).

Because P3-AR to R-HOT has been associated with externalizing conditions, which are characterized by diminished behavioral control, researchers have suggested that P3-AR to R-HOT may be a potential neurophysiological marker for trait disinhibition (see Iacono et al., 2003; Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001). In support of this notion, Moeller and colleagues (2004) reported a negative correlation between a self-report measure of disinhibition and P3 amplitude elicited by neutral visual oddball cues in a sample of cocaine-dependent subjects and normal controls. Another study involving college students also found that P3-AR to target letters (X or O) predisposed males to rash, impulsive behaviors, which in turn promoted the development of alcohol problems (Justus et al., 2001). Overall, data suggest that reduction in the P3-AR elicited by neutral visual cues may serve as a useful neurophysiological indicator for trait disinhibition (Harmon-Jones, Barratt, & Wigg, 1997; Russo, Pascalis, Varriale, & Barratt, 2008).

While alcohol outcome expectancies are commonly assessed using self-report questionnaires and laboratory tasks, recent work has begun utilizing ERP techniques to relate external expectancy measures to brain actions (Fishman et al., 2008). Results indicated that increases in P3 elicited by alcohol expectancy words are positively associated with self-reported positive alcohol expectancies (Fishman et al., 2008). Furthermore, data from separate lines of research have indicated that both strong positive expectancies and increased P3 elicited by alcoholic beverage cues relate to liability for alcohol use disorder and prospective drinking behavior (Bartholow et al., 2007; Bartholow

et al., 2010). For instance, Bartholow and colleagues (2007) have shown that individuals at risk for alcohol problems (i.e., low sensitivity to alcohol) exhibit greater alcohol-cue P3 compared to those not at risk. It is important to note that this effect is specific to alcohol cues and does not generalize to other arousing or appetitive cues (e.g., nudity, sky diving; Bartholow et al., 2010). Taken together, this previous work suggests that the differences in the amplitude of P3 elicited by alcohol visual cues may serve as a useful index of one's cognitions about alcohol and its motivational significance.

While the functional significance of the P3 remains unclear, it is believed to be sensitive to both the arousal properties and the motivational significance of eliciting stimuli (Nieuwenhuis, Aston-Jones, & Cohen, 2005), which may explain its differential response to neutral and alcohol visual stimuli. Several theorists have hypothesized that both hypo- and hyper-arousal states attribute to disinhibited behavior by reducing one's ability to attend to target stimuli and respond appropriately (Aston-Jones, Rajkowski, & Cohen, 2000; Raine, Lencz, Bihrlé, LaCasse, & Colletti, 2000; Raine, Venables, & Williams, 1990a, b; Scarpa, 2015). Furthermore, individuals with disinhibitory conditions, such as antisocial personality disorder and attention deficit hyperactivity disorder, have been found to exhibit hyper- and hypo-arousal baseline levels (for review, see Scarpa, 2015). Thus, P3-AR elicited by neutral visual cues, such as R-HOT, may reflect conditions of low or excessive arousal, which presumably increases rash, disinhibited behaviors (Iacono et al., 2003). At the same time, P3 response is also believed to reflect the activation of appetitive motivational state by the eliciting stimuli. Thus, the greater the P3 response elicited by a target stimulus the more motivationally significant the stimulus is to the individual (Nieuwenhuis et al., 2005). Viewed in this context, enhanced P3 response to alcohol-

related cues likely reflects a stronger motivational response to alcohol, which may also be related to alcohol-specific psychosocial learning factors (Fishman et al., 2008).

Summary of Present Project and Hypotheses

In summary, the primary aim of the present project was to test the APM using both self-report and ERP approaches. Individual differences in both reward sensitivity (index of trait disinhibition) and alcohol outcome expectancies (alcohol-related cognitive process) were measured using self-report questionnaires. Differences in the P3s elicited by R-HOT and alcoholic beverage target pictures were also employed as neurophysiological markers of trait disinhibition and alcohol-related cognitive process, respectively. This multi-method approach allowed for the detection and extraction of common method variance by using a multitrait-multimethod (MTMM) matrix (Campbell & Fiske, 1959) and latent variable approaches (Podsakoff et al., 2003). A secondary aim of the present project was to extend previous research by examining how self-report measures of general risk factors and alcohol-related cognitive factors related to their respective neurophysiological markers (i.e., cross-method convergence). Specifically, we were interested in understanding the extent to which P3 amplitude elicited by RHOT related to reward sensitivity and the extent to which alcohol-cue P3 related to alcohol outcome expectancies.

Based on prior findings (e.g., Justus et al., 2001; Russo et al., 2008), we hypothesized (Hypothesis 1) that individual differences in reward sensitivity and reactivity of the P3 to RHOT would be strongly and negatively associated. Furthermore, we anticipated that this association would be greater than the associations these variables have with other variables for which they have the same method of measurement (monotrait-heteromethod > heterotrait-monomethod). Given the findings from Fishman and colleagues

(2008), we hypothesized (Hypothesis 2) that alcohol outcome expectancies and P3 amplitude elicited by alcohol cues would be strongly and positively associated with one another, and that this association would be greater than the associations these variables have with other variables for which they share the same method (monotrait-heteromethod > hetertrait-monomethod).

In line with the tenets of the APM, we hypothesized (Hypothesis 3) that general risk factors (i.e., reward sensitivity and P3 to R-HOT) would be significantly related to both self-report and neurophysiological indicators of alcohol-related expectancies (i.e., alcohol outcome expectancies, P3 to alcohol cues). However, we anticipated the magnitude of these associations to be smaller than that for indicators of the same trait assessed using different methods (heterotrait-monomethod/heterotrait-heteromethod < monotrait-heteromethod). Furthermore, we hypothesized (Hypothesis 4) that stronger positive alcohol outcome expectancies and increased alcohol-cue P3 would have a stronger relation with alcohol problems than illicit drug use and antisocial behavior, indicating their specificity to alcohol problems. Lastly, we hypothesized (Hypothesis 5) that alcohol outcome expectancies and alcohol-cue P3 would partially mediate the effect of general risk factors on alcohol problems but not other externalizing behaviors.

METHOD

Participants

One hundred and fifty-two participants (95 female), ages 18-30 ($M = 21.88$, $SD = 2.99$), were recruited from a large, Midwestern university and its surrounding community via flyers and university informational emails. Potential participants were initially screened for eligibility via a telephone interview. Eligible participants were required to be fluent in English and between the ages of 18 to 30 years old, as this age range has the highest prevalence of alcohol use disorder (Grant et al., 2006). Respondents were excluded if they reported current or past attempts to quit drinking, endorsed alcohol withdrawal symptoms, or affirmed a history of head trauma or neurological disorder. Respondents who had synthetic hair or cornrows were also excluded, as these hair styles impede ERP data collection. Two female participants were unable to complete the entire study—one due to illness and one due to synthetic hair. Due to computer error, data from two participants were not collected.

Measures

Drinking behaviors. Typical alcohol use behaviors were assessed using six items from National Institute on Alcohol Abuse and Alcoholism Task Force on Recommended Alcohol Questions (NIAAA, 2003). Items assessed past-year frequency and quantity of consumption, and frequency of heavy episodic drinking.

Alcohol Outcome Expectancies. The Comprehensive Effects of Alcohol (CEOA; Fromme, Stoot, Kaplan, 1993) was used to assess positive and negative alcohol outcome expectancies. Participants indicated whether they expect a list of 38 behaviors and feelings (20 positive, 18 negative) to occur while under the influence of alcohol. The CEOA

consists of four positive expectancy subscales (Sociability, Sexuality, Tension Reduction, Liquid Courage) and three negative subscales (Cognitive & Behavior Impairment, Risk & Aggression, Self-Perception). Positive and negative subscales were aggregated separately to generate mean positive and negative expectancy scores. Cronbach's alphas of .87 (positive expectancies) and .80 (negative expectancies) for mean scores suggest good internal consistency in the present sample.

Sensitivity to Reward. The Sensitivity to Reward (SR) subscale from the Sensitivity to Punishment Sensitivity to Reward (SPSRQ; Torrubia, Ávila, Moltó, & Caseras, 2001) was used to assess variability in reward sensitivity. Participants responded to items pertaining to appetitive motivation ("Do you sometimes do things for quick gain?"), using a binary (yes/no) response option. Item responses were aggregated to generate a mean reward sensitivity score. Cronbach's alpha of .77 for the SR subscale in the present sample indicates good internal consistency.

Externalizing problems. The short form of the Externalizing Spectrum Model (ESM; Krueger, Markon, Patrick, Benning, & Kramer, 2007) questionnaire was used to assess alcohol use problems, substance use problems, and antisocial behavior. The ERM consists of 100 items that evaluate twelve distinct externalizing related constructs and behaviors. Participants indicated how much each item described them using a 4-point scale with response options *true*, *somewhat true*, *somewhat false*, and *false*. For the present study, alcohol use problems were assessed by the Alcohol Problems scale; substance use problems were assessed by the Marijuana Problems and Drug Problems scales; and antisocial behavior was assessed by the Theft, Physical Aggression, Relational Aggression, Destructive Aggression, and Fraud scales. Cronbach's alpha of .78, .92, and .90 for alcohol

use problems, substance use problems, and antisocial behavior, respectively, suggests good internal consistency.

General Visual Oddball Task (Rotated Heads Task). Participants completed a classic visual oddball task (rotated-head oddball paradigm; Begleiter et al., 1984). In this task, 240 stimuli were presented randomly one at a time for 98 ms each, with the intertrial interval varying randomly between 1000 and 2000 ms. Participants were required to maintain their gaze on a fixation cross in the center of the computer screen during the intertrial interval. On two-thirds of the trials, participants saw a plain oval to which they were instructed not to respond. On the remaining third of the trials, participants saw an oval with a nose and an ear (target trial). Participants were instructed to press one of two keyboard buttons to indicate whether the ear was on the left or right side of the head. Half of these target trials comprised of heads with the nose pointed up, such that the stylized head was oriented in the same direction as the participant (normal-head oddball targets; N-HOT). The other half comprised of heads that were rotated 180° with the nose pointed down, such that they were oriented in the opposite direction of the participant (rotated-head oddballs targets; R-HOT). The response to rotated heads is presumed to be more difficult than the response to normal heads.

Alcohol Cue Oddball Task. Participants also completed a modified oddball picture viewing task (Bartholow et al., 2010) that involved five groups of colored pictures: alcoholic beverages, non-alcoholic beverages, adventurous scenes (e.g., people sky-diving), erotic scenes (e.g., people partially nude), and neutral scenes (e.g., a bus). Pictures were obtained from both the Normative Appetitive Picture System (NAPS; Breiner, Stritzke, Lang, & Patrick, 1995; Stritzke, Breiner, Curtin, & Lang, 2004) and the

International Affective Picture System (IAPS; Bradley & Lang, 2007). Valence (scaled 1 = very negative to 9 = very positive) and arousal (scaled 1 = completely calm to 9 = completely excited) ratings for each picture group are as follows: Neutral: $M_{\text{valence}} = 5.02$, $M_{\text{arousal}} = 2.82$; Nonalcoholic: $M_{\text{valence}} = 4.40$, $M_{\text{arousal}} = 3.63$; Alcohol: $M_{\text{valence}} = 4.42$, $M_{\text{arousal}} = 4.35$; Adventurous: $M_{\text{valence}} = 7.35$, $M_{\text{arousal}} = 6.89$; Erotic: $M_{\text{valence}} = 6.89$, $M_{\text{arousal}} = 5.92$ (Bradley & Lang, 2007; Breiner et al., 1995). For each trial, five pictures were presented one at a time, with four of the pictures being from the neutral group. Target pictures from which P3 responses were derived for analyses were presented in the fourth or fifth position within the sequence and were equally likely to represent each of the five picture groups. The task consisted of 100 trials (500 total pictures viewed), such that participants viewed each group of pictures in the target position 20 times. Participants were required to categorize the pictures by key press as either neutral or pleasurable. Pictures were presented for 1,000 ms, with the interstimulus interval varying randomly between 900 and 1,200 ms. The inter-trial interval was 500 ms.

Procedures

Participants attended a single session in the Social Cognitive Neuroscience laboratory at the University of Missouri. Participants provided informed consent upon arrival and then completed all self-report questionnaires. Next, participants were fitted with EEG recording electrodes in an EEG acquisition suite. After attaching the electrodes and reducing impedance, ERP data was recorded while participants complete the standard visual oddball task (i.e., rotated head task) and modified oddball picture viewing task in a counterbalanced order. Following completion of the tasks, electrodes were removed and participants were able to wash up in a private restroom setup with a shower. Participants

were debriefed before leaving the laboratory. Compensation for participation involved a flat rate of \$10 per hour. Total time to complete the study was approximately 2.5 hours.

Electrophysiological Recording, Preprocessing, and ERP Component Averaging

Due to equipment failure, electroencephalogram (EEG) data were not collected for two participants. EEG data were recorded from 28 standard scalp locations (Pivik et al., 1993) using silver/silver chloride electrodes fixed in a stretch-lycra cap. EEG was sampled continuously at 1000 Hz and amplified and filtered online at .01 to 40 Hz using a Neuroscan Synamps 1 amplifier. Scalp electrodes were referenced to the right mastoid online; an average mastoid reference was derived offline. Impedance for all channels was kept below 10K Ω . Electrodes were also placed above and below the left eye to record ocular artifacts (i.e., eye movement), which were corrected offline using a regression-based procedure (Semlitsch, Anderer, Schuster, & Presslich, 1986). Epochs of 1300 ms (including 100 ms pre-stimulus baseline) were derived from all stimulus events. Data were baseline-corrected based on the 100 ms pre-stimulus epoch. Visual inspection of each epoch was completed to identify and reject artifacts prior to averaging.

After artifact rejection, ERP waveforms were constructed for each participant by averaging the EEG data across trials within the different target conditions of the tasks at each scalp electrode. For the picture viewing task, five separate average waveforms (at each of the 28 electrode sites) based on target type—Alcohol, Non-Alcohol, Adventurous, Erotic, and Neutral—were obtained for each participant. Likewise, two average waveforms (again, at each electrode site) based on target type—N-HOT and R-HOT—were obtained from the rotated head task for each participant. In line with prior research involving the rotated head task (e.g., Carlson, Thai, & McLarnon, 2009; Iacono et al., 2002; Malone,

Iacono, & McGue, 2001; Wan, Baldrige, Colby, & Stanford, 2010), only trials associated with correct behavioral responses contributed to ERPs. Consequently, data from thirteen participants were excluded from analyses due to excessive incorrect responses (i.e., accuracy = 0).

Data Analysis

A multi-trait, multi-method (MTMM) matrix (Campbell & Fiske, 1959) was employed to examine the cross-method convergence (Hypothesis 1 & 2) of the different general risk factors (i.e., reward sensitivity and P3 to R-HOT) and alcohol-related cognitive processes (i.e., alcohol outcome expectancies and alcohol-cue P3). The MTMM matrix approach proposed by Campbell and Fiske (1959) entails examining the intercorrelations of two or more traits measured by two or more methods (see Table 1). According to Campbell and Fiske (1959), cross-method convergence can be determined by examining the correlations of different indicators of the same trait that are measured using different methods (e.g., reward sensitivity and P3 to R-HOT). The magnitude of these monotrait-heteromethod correlations represents the extent to which the indicators reflect the same underlying constructs (general risk factor or alcohol-related cognitive processes). Thus, the correlation between reward sensitivity and P3 to R-HOT (Hypothesis 1) and that between alcohol expectancies and alcohol-cue P3 (Hypothesis 2) were expected to be significantly different from zero and sufficiently large. These correlations are represented in Table 1 by the letters in boldface type (e.g., **a** and **b**).

The extent to which common method variance affected the association between general risk factors and alcohol-related cognitive processes was also examined using the MTMM matrix. Again, according to Campbell and Fiske (1959), method effects are

considered trivial if two conditions are met. First, the association between reward sensitivity and P3 to R-HOT (monotrait-heteromethod) should be greater than the association they have with variables in which they share the same method of measurement (heterotrait-monomethod). A similar pattern of associations should be observed for alcohol expectancies and alcohol-cue P3. Thus, in Table 1, the magnitude of the correlation coefficients **a** and **b** should be larger than that of *c* and *d*. Second, the extent to which reward sensitivity is related to alcohol expectancies (heterotrait-monomethod) should be similar to its relation with alcohol-cue P3 (heterotrait-heteromethod). The difference between these associations will reflect the degree to which method contributed to the associations. A similar pattern of associations should be observed for P3 to R-HOT with alcohol-cue P3 and alcohol outcome expectancies. Thus, in Table 1, the magnitude of the correlation coefficients *c* and *d* should be equivalent to that of *e* and *f*, respectively.

The MTMM matrix was used to test the requirements for mediation (MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002). According to MacKinnon and colleagues (2002), mediation is possible if (1) predictor variables have direct effects on mediator variables (Hypothesis 3) and (2) mediator variables have direct effects on outcome variables (Hypothesis 4). While others have required a direct effect of the predictor on the outcome (Baron & Kenny, 1986), Mackinnon and colleagues (2002) make no such requirement. Figure 1 depicts the proposed mediational model to be tested in the proposed project. Those variables that met the requirements for mediation were included in the mediation analyses.

Indirect effects test were conducted in Mplus version 7.0 (Muthén & Muthén, 2011) to determine whether alcohol expectancies and alcohol-cue P3 reactivity mediate the

effects of reward sensitivity and P3 to R-HOT on alcohol problems while accounting for other substance use problems and antisocial behavior (Hypothesis 5). Preliminary examination of dependent variables revealed that data for alcohol use problems, substance use problems, and antisocial behavior were moderately non-normally distributed (skewness range: 1.88 to 2.41; kurtosis range: 3.43 to 5.59). A number of simulation studies (Finch, West, & MacKinnon, 1997; Lei & Lomax, 2005; West, Finch, & Curran, 1995) suggest that maximum likelihood estimation can produce biased standard errors and incorrect test statistics in the presence of moderate to severe skewness and/or kurtosis in the data. Therefore, maximum likelihood estimation with robust standard errors (MLR estimator) was specified for mediation analysis, as this method of estimation has been shown to produce more accurate standard errors and test statistics in the presence of moderate to severe nonnormality (see Finch et al., 1997). The product of coefficients method was used to compute the specific indirect effect estimates for each mediator. Estimates and their standard errors were used to calculate z-statistics to determine significance. Bias-corrected bootstrap resampling methods were used to obtain confidence intervals for z-statistics (Mackinnon, Lockwood, & Williams, 2004). Significant results would indicate at least partial mediation. Drinking frequency and quantity, as well as sex, will be included in the mediation model as covariates.

Power Calculations. Recently, Fritz and MacKinnon (2007) recommended sample sizes to detect mediated effects based on expected effect sizes and the testing methods (e.g., Sobel test, bias-corrected bootstrap). Prior research has consistently found medium to large effect sizes between the variables in the proposed project (Bartholow et al., 2007, 2010; Iacono et al., 2002; McCarthy et al., 2001a, b). Based on Fritz and MacKinnon's (2007)

recommendations, it was determined that a sample size of 148 individuals would be adequate using bias-corrected bootstrap resampling methods to detect a medium effect ($d = .5$) with power $(\beta - 1) = .80$ and using $\alpha = .05$, two-tailed.

RESULTS

Descriptive Statistics

The final sample ($n = 137$) was 59% females and had a mean age of 22 years ($SD = 3$). Participants were primarily Caucasian ($n = 124$), with nine African Americans and three Asians (one did not report race). Table 2 presents descriptive statistics for demographic variables stratified by gender. Approximately 63% of the present sample reported being of legal age to drink in the United States (e.g., ≥ 21 years old). Nonetheless, the majority of the sample (97%) indicated that they had consumed at least one drink of alcohol at some point in their life. Of those who reported lifetime use, approximately 23% reported monthly use, 40% reported weekly use, and 17% reported almost daily use. Most drinkers (65%) consumed three or more alcoholic beverages per occasion, and approximately 42% of drinkers reported having two or more heavy drinking episodes per month. Table 2 also presents descriptive statistics for alcohol use variables stratified by gender.

Results from chi-square test indicated that males typically consumed a larger quantity of alcohol per occasion compared to females, $\chi^2(4) = 9.85$, $p < .05$. No gender differences were observed for typical drinking frequency or frequency of heavy episodic drinking ($ps > .42$). Likewise, no gender differences were observed in the occurrence of alcohol-related problems ($p > .32$). Typical frequency and quantity of drinking were positively correlated with alcohol-related problems (rs ranged from .20 to .33, $ps < .05$). Independent sample t -tests indicated that males and females held comparable expectations about the positive and negative effects of alcohol ($ps > .70$). Lastly, results indicated that

males reported greater sensitivity to reward, but not punishment, compared to females, $t(153) = 4.22, p < .001, d = .69$.

Picture Viewing Task

The proportion of positive responses to target cues on the picture viewing task was analyzed with a 2 (Gender) \times 5 (Target type) mixed factorial analysis of variance (ANOVA) with repeated measures on the latter factor. Only a significant main effect of target type was observed, $F(4, 580) = 135.90, p < .001, \eta_p^2 = .48$. Proportion means revealed that adventurous and erotic were most likely to be categorized as pleasant ($M_s = .79$ & $.76$, respectively), followed by alcohol and non-alcohol targets ($M_s = .55$ & $.58$, respectively), and lastly neutral targets ($M = .18$). This pattern of categorization is comparable to that observed in previous work (Bartholow et al., 2010). Bonferroni-corrected follow-up pairwise comparisons indicated that the proportions of adventurous and erotic targets categorized as pleasant were comparable, as were those for alcohol and non-alcohol targets. All other comparisons were significantly different ($p < .001$).

P3 Reactivity

Rotated Head Task

Figure 2 depicts topographic “heat” maps of the scalp voltage during the time window of the P3 component elicited by N-HOT and R-HOT were visually inspected to determine the distribution of the P3 elicited by each target type. Visual inspection of the maps revealed that P3 was largest at midline parietal electrodes. Figure 2 also depicts the ERP waveforms elicited at the Pz electrode by each of the target types. Waveforms for N-HOT and R-HOT were averaged together (henceforth referred to as NR-HOT) as has been common practice in prior work due to the moderate to high correlations between the P3

responses elicited by the different target stimuli (Carlson et al., 2009; Iacono et al., 2002). Consistent with this prior research, results indicate that the extent to which P3 was elicited by each target type was significantly correlated at frontal ($.53 \leq r \leq .61$), central ($.57 \leq r \leq .70$), and parietal ($.64 \leq r \leq .69$) scalp sites, $ps < .001$.

Preliminary analyses were also conducted to determine the distribution of the P3 elicited by NR-HOT using a 5 (Coronal location: frontal, fronto-central, central, centro-parietal, parietal) \times 3 (Lateral location: left, midline, right) repeated measures ANOVA. This analysis focused on data from a set of 15 scalp locations, representing electrodes at which the P3 was most visible (F3, Fz, F4, FC3, FCz, FC4, C3, Cz, C4, CP3, CPz, CP4, P3, Pz, P4). Greenhouse-Geisser corrected p values are reported for all repeated measures analyses. A significant main effect of Coronal location, $F(4, 544) = 69.63$, $p < .001$, $\eta_p^2 = 0.34$, such that P3 increased linearly from more anterior ($M = 1.66 \mu\text{V}$) to more posterior scalp locations ($M = 7.31 \mu\text{V}$), as is typical (see Fabiani, Gratton, Federmeier, 2007). While the Coronal location \times Lateral location interaction was not significant ($p = .18$), pairwise comparison indicated that the P3 was most pronounced at the midline parietal electrode (Pz: $M = 8.16 \mu\text{V}$) compared to the left-hemisphere (P3: $M = 6.69 \mu\text{V}$) and right-hemisphere (P4: $M = 7.08 \mu\text{V}$) parietal locations. Based on these results and visual inspection of topographic “heat” maps, P3 data from Pz and CPz electrodes for NR-HOT were averaged ($M = 7.65$, $SD = 3.71$) and utilized in all subsequent analyses.

Picture Viewing Task

Figure 3 depicts topographic “heat” maps of the scalp voltage distribution during the time window of the P3 component for each of the five target types of the picture viewing task. As with the rotated head task, visual inspection of the maps again revealed

that P3 was largest at midline parietal electrodes. Figure 3 also depicts the ERP waveforms elicited at the Pz electrode by each of the target types. To determine the distribution of the P3 elicited by alcohol targets, a 5 (Coronal location) \times 3 (Lateral location) repeated measures ANOVA focusing on the same 15 scalp locations was conducted. Similar to that observed with the rotated head task, results from this analysis indicated a main effect of Coronal location, $F(4, 488) = 186.06, p < .001, \eta_p^2 = 0.60$, such that P3 increased linearly from more anterior ($M = 0.41 \mu\text{V}$) to more posterior scalp locations ($M = 5.31 \mu\text{V}$). A significant Coronal location \times Lateral location interaction, $F(8, 976) = 8.68, p < .001, \eta_p^2 = 0.07$, indicating that the P3 was most pronounced at the midline parietal electrode (Pz: $M = 5.52 \mu\text{V}$) compared to the left-hemisphere (P3: $M = 5.04 \mu\text{V}$) and right-hemisphere (P4: $M = 5.30 \mu\text{V}$) parietal locations ($ps < .05$). Based on these results and visual inspection of topographic “heat” maps, alcohol-cue P3 data from Pz, CPz and CP4 electrodes were averaged ($M = 5.28, SD = 3.60$) and utilized in all subsequent analyses.

MTMM Correlation Matrix

Table 3 presents the MTMM correlation matrix for the different indices of general risk factors (i.e., reward sensitivity and P3 to NR-HOT) and alcohol-related cognitive processes (i.e., alcohol outcome expectancies and alcohol-cue P3). Contrary to Hypothesis 1, the cross-method convergence (monotrait-heteromethod) between reward sensitivity and P3 to NR-HOT was poor ($p > .95$), indicating that these variables reflect separate underlying processes of general risk. Results also demonstrated, contrary to Hypothesis 2, that the cross-method convergence between alcohol expectancies, both positive and negative, and alcohol-cue P3 was trivial ($ps > .21$). Again, this lack of cross-method

convergence indicates that these indicators for the motivational salience of alcohol may reflect distinct processes that are only modestly related.

Next, we used the MTMM correlation matrix to examine the extent to which common method variance influenced the associations between the different measures of general risk and alcohol-related cognitive processes. First, results indicated that the correlations among measures that share the same method of measurement (heterotrait-monomethod) were all significant, with magnitudes ranging from small to medium (self-report measures: $r_s = .19$ to $.33$, $p_s < .05$; neurophysiological measures: $r = .38$, $p < .001$). Compared to the magnitude of the monotrait-heteromethod (e.g., correlation for reward sensitivity with P3 to NR-HOT), these heterotrait-monomethod correlations were markedly larger (see Table 3), suggesting a strong method effect. The MTMM correlation matrix also shows that the magnitude of the correlation for reward sensitivity with alcohol-cue P3 was much smaller than that between reward sensitivity and alcohol expectancies (both positive and negative). Similarly, the magnitude of the correlation for P3 to NR-HOT with alcohol expectancies was substantially less than that between the two P3 reactivity measures. Given that these correlations share the same method, but not trait, the differences in their magnitudes indicates a strong effect of method on the association between variables (Campbell & Fisk, 1959).

Relations among General Risk Factors, Cognitive Processes, and Externalizing Behaviors

To determine the feasibility of the proposed mediation models, we first examined bivariate associations among indices of general risk factors, alcohol-related cognitive processes, and externalizing behaviors (see Table 3). Reward hypersensitivity was

significantly associated with more frequent drinking, greater drinking quantity, more substance use problems, and more antisocial behaviors, but it was not significantly associated with alcohol problems ($p = .23$). This general risk factor also was significantly associated with stronger alcohol expectancies (both positive and negative, $ps < .05$) and marginally with heightened alcohol-cue P3 ($p < .10$). Reactivity of the P3 to NR-HOT was split into heightened ($n = 69$) and diminished ($n = 68$) response based on the median (median = 7.88 μV). Response of the P3 to NR-HOT was not significantly associated with alcohol use or its associated problems, substance use problems, or antisocial behavior. Greater P3 response to NR-HOT was significantly associated with greater alcohol-cue P3 ($t = 3.31, p < .001, d = 0.57$), but it was not associated with positive and negative alcohol expectancies. Stronger negative expectancies were significantly associated with more alcohol-related problems ($p < .05$), but positive expectancies were not associated with such problems. ($p = .30$). More positive alcohol-cue P3 were marginally related to more alcohol-related problems but did not reach statistical significance ($p < .10$). Positive expectancies, however, were significantly and positively related to drinking frequency and quantity, substance use problems, and antisocial behaviors. Greater negative alcohol expectancies were also associated with more antisocial behaviors, and greater alcohol-cue P3 was associated with more frequent alcohol use.

Mediation Analyses (Hypothesis 5)

According to Mackinnon and colleagues (2002), a significant direct effect from a predictor to a mediator and a mediator to an outcome variable are required for mediation, but the direct effect from the predictor to the outcome variable does not need to be significant. Therefore, although neither reward sensitivity nor P3 to NR-HOT were

uniquely associated with alcohol problems, we still tested indirect effects from reward sensitivity and P3 to NR-HOT through alcohol-cue P3 and reward sensitivity through negative expectancies in separate mediation models. We also tested whether positive alcohol expectancies and alcohol-cue P3 mediated the effect of reward sensitivity on drinking frequency in separate models. The indirect effect of positive expectancies on the association between reward sensitivity and drinking quantity was also examined. Given the significant association of alcohol expectancies (both positive and negative) with antisocial behavior, indirect effects from reward sensitivity through alcohol expectancies were tested in separate models. We also examined whether positive alcohol expectancies mediated the association between reward sensitivity and substance use problems. All mediation analyses controlled for the influence of sex and typical drinking frequency and quantity on all dependent variables and included substance use problems and antisocial behaviors as dependent variables.

Standardized parameter estimates for the examined indirect effects are presented in Table 4. Standardized path coefficients for significant mediation models are also presented in Figure 4. Negative alcohol expectancies, but not alcohol-cue P3, mediated the association between reward sensitivity and alcohol-related problems (indirect effect estimate = 0.06; 95%CI: 0.02 – 0.10; $z = 2.62$; $p < .01$). As depicted in Figure 4a, results indicate that greater reward sensitivity was associated with stronger negative alcohol expectancies, which in turn was associated with greater alcohol-related problems. In regard to drinking behaviors, positive expectancies, but not alcohol-cue P3, partially mediated the association between reward sensitivity and drinking frequency (indirect effect estimate = 0.07; 95%CI: 0.02 – 0.13; $z = 2.49$; $p < .05$). Figure 4b shows that greater reward sensitivity

was associated with stronger expectancies about the positive outcomes of drinking, which was also associated with more frequent alcohol use.

Interestingly, results also indicated that the observed indirect effects of negative and positive expectancies were not unique to alcohol-related problems. Specifically, a marginally significant path from reward sensitivity to antisocial behavior through negative expectancies was observed (indirect effect estimate = 0.04; 95%CI: 0.00 – 0.07; $z = 1.95$; $p = .05$). Figure 4a shows that greater reward sensitivity was associated with stronger expectancies about the negative outcomes of drinking, which was associated with greater self-reported antisocial behavior. Positive expectancies were also found to partially mediate the effect of reward sensitivity on substance use problems (indirect effect estimate = 0.07; 95%CI: 0.02 – 0.11; $z = 2.72$; $p < .01$), even when controlling for drinking quantity (indirect effect estimate = 0.06; 95%CI: 0.01 – 0.10; $z = 2.43$; $p < .05$). As displayed in Figure 4c/d, greater reward sensitivity was associated with stronger positive outcome expectancies for alcohol, and stronger positive expectancies were related to more reported problems related to substance use.

Results also indicated that alcohol-cue P3 marginally mediated the effect of P3 to NR-HOT on alcohol problems (indirect effect estimate = 0.05 [SE = 0.03]; $z = 1.81$; 95%CI: -0.00 – 0.02; $p = .07$). Figure 5a shows that greater P3 to NR-HOT was associated with greater alcohol-cue P3, which was related to greater alcohol problems. A marginally significant indirect path from P3 elicited by NR-HOT to drinking frequency through alcohol-cue P3 was also observed (indirect effect estimate = 0.08 [SE = 0.04]; $z = 1.74$; 95%CI: -0.01 – 0.15; $p = .08$). Specifically, results indicated that greater P3 to NR-HOT

was associated with greater alcohol-cue P3 ($\beta = .32, p < .01$), which was related to more frequent drinking ($\beta = .22, p < .05$).

To test for potential method effects, mediation analyses including P3 variables were conducted again with the addition of a latent common method variance factor (see Figure 5b). This latent factor was obtained using confirmatory factor analyses with P3 to each tasks' stimuli (e.g., NR-HOT, alcohol, non-alcohol, erotic, adventurous) as separate indicators. Most factor loadings were greater than 0.84 with the smallest loading being 0.45. Results demonstrated that with the inclusion of the latent common method variance factor, alcohol-cue P3 no longer mediated the association between P3 to NR-HOT and alcohol problems (indirect effect estimate = 0.00 [SE = 0.01]; $z = 0.03$; 95%CI: -0.03 – 0.03; $p = .98$). Likewise, the marginally significant indirect effect of P3 to NR-HOT to drinking frequency through alcohol-cue P3 was no longer significant after accounting for method variance (indirect effect estimate = 0.01 [SE = 0.02]; $z = 0.03$; 95%CI: -0.03 – 0.04; $p = .98$). For both mediation models, the association between P3 to NR-HOT and alcohol-cue P3 was attenuated and no longer significant ($\beta = .00, p = .98$) after extracting the method variance shared between the two indicators.

Given the differences in stimulus complexity across tasks, two separate P3 reactivity difference scores were computed as an alternative approach for extracting method variance. For the rotated head task, P3 reactivity to N-HOT was subtracted from P3 to R-HOT ($M = -0.44, SD = 3.38$). Likewise, P3 reactivity to non-alcohol targets was subtracted from alcohol-cue P3 ($M = 1.09, SD = 3.35$) for the picture viewing task. Similar to results from the mediation analyses including the latent common method variance, results indicated that with the utilization of the P3 reactivity difference scores, alcohol-cue

P3 did not mediate the association between P3 to NR-HOT and alcohol problems (indirect effect estimate = 0.001 [SE = 0.004]; $z = 0.27$; 95%CI: -0.01 – 0.01; $p = .79$). Likewise, alcohol-cue P3 did not mediate the association between P3 to NR-HOT and drinking frequency (indirect effect estimate = -0.01 [SE = 0.01]; $z = -0.68$; 95%CI: -0.03 – 0.01; $p = .49$). For both mediation models, the association between P3 to NR-HOT and alcohol-cue P3 was attenuated and no longer significant ($\beta = -.06$, $p = .42$) after extracting the method variance shared between the two indicators.

DISCUSSION

The primary aim of the present study was to replicate prior research supporting the acquired preparedness model (Smith & Anderson, 2001) and to extend this work by testing the tenets of this model using both self-report and neurophysiological approaches. Consistent with previous studies on the acquired preparedness model (Lopez-Vergara et al., 2012; McCarthy et al., 2001a, b; Wardell et al, 2012), the results support a mediation pathway through which positive alcohol expectancies partially account for the effect of reward sensitivity on drinking frequency. Results also found an indirect path from reward hypersensitivity to alcohol problems through greater negative expectancies, which is contrary to previous findings (Lopez-Vergara et al., 2012; McCarthy et al., 2001a). Although results suggested that neural reactivity to alcohol cues partially mediated the association between neural reactivity to neutral cues and alcohol problems, this mediation pathway was no longer supported after extracting common method variance. Findings also implied little convergence across self-report and neurophysiological indices of general risk and alcohol-related cognitive processes. These findings suggest an effect of measurement method and provides evidence that at least a portion of the observed associations in the mediation models are attributable to shared method variance.

Consistent with the acquired preparedness model (Lopez-Vergara et al., 2012; McCarthy et al., 2001a,b; Wardell et al, 2012), there was evidence that positive expectancies mediated the relationship between reward hypersensitivity (an indicator of behavioral disinhibition) and drinking frequency, but not alcohol problems. Interestingly, the mediational role of positive alcohol expectancies was not unique to alcohol use. Instead, results indicated that positive expectancies about the acute effects of alcohol also

mediated the relationship between reward sensitivity and substance use problems. Prior research with adolescent users and non-users of alcohol and cannabis reported that alcohol and cannabis expectancies are moderately and positively correlated, and that longitudinally greater alcohol use increases positive expectancies about not only the consequences of drinking but also cannabis use (Willner, 2001). These prior findings may provide some explanation for the indirect effect of positive alcohol expectancies on substance use problems. Specifically, the acquisition of more positive alcohol-related expectancies among individuals hypersensitive to reward may reflect the formation of more positive drug-related expectancies, which may result in subsequent substance use problems. The present study was not designed to evaluate this hypothesis as other drug-related expectancies were not assessed. An important aim for future research is to better understand how alcohol expectancies might contribute to other substance use problems.

Although the indirect effect of positive alcohol expectancies has been the focus of several previous studies on the association between reward sensitivity and alcohol use (Lopez-Vergara et al., 2012; McCarthy et al., 2001a,b; Wardell et al, 2012), research on the indirect effect of negative alcohol expectancies has been limited. The present results demonstrated that greater negative expectancies mediated the influence of reward hypersensitivity on alcohol problems. Based on the acquired preparedness model, individuals more sensitivity to reward should form more positive, not negative, expectancies about the outcomes of drinking alcohol. However, individuals hypersensitive to reward also consume larger quantities of alcohol (Johnson et al., 2003; Lyvers et al., 2009; O'Connor & Colder, 2005; Pardo, Aguilar, Molinueva, & Torrubia, 2007) presumably because they are more receptive to alcohol's acute reinforcing effects (Dawe,

Gullo, & Loxton, 2004; Morris, Treloar, Tsai, McCarty, & McCarthy, 2016). This heavier drinking is likely to lead to more negative consequences with alcohol (Wechsler, Lee, Kuo, & Lee, 2000), which may in turn lead to the formation of more negative expectancies about the effects of drinking. Thus, reward hypersensitivity may lead to greater alcohol problems through excessive consumption, which may in turn lead to the acquisition of greater negative expectancies. However, due to the cross-section nature of the present study, it is not possible to determine the directionality of the association between reward sensitivity, negative alcohol expectancies, and alcohol-related problems.

The present study is the first to examine the tenets of the acquired preparedness model using neurophysiological markers. Although differences in neural reactivity to alcohol cues appeared to mediate the association between neural reactivity to neutral cues and alcohol problems, further examination indicated that this was largely due to shared method variance. After accounting for the common method by which neurophysiological markers were measured, results suggested that P3 to NR-HOT was only modestly associated with P3 response to alcohol cues, thereby, reducing the potential for mediation. The present findings demonstrate how the effects of shared measurement method on the observed association between variables can lead to spurious results and misspecification of theoretical models. While the present results indicate the presence of a strong method effect for neurophysiological markers, current methodology limited the ability to statistically extract method variance from mediation models based on self-report measures. It will be important for future studies to incorporate three or more self-report measures to allow more precise detection and extraction of measurement method effects (see Podsakoff et al., 2003).

In addition to demonstrating the presence of a strong method effect in the present study, results also indicated little convergence between self-report and neurophysiological indices of risk factors for alcohol problems. This is consistent with prior studies reporting that self-report and objective approaches to construct measurement are only modestly correlated with one another (Cyders & Coskunpinar, 2011, 2012; Reynolds, Ortengren, Richards, & de Wit, 2006; Unruh et al., 2008). There are several issues involved in efforts to relate self-report based trait measures and objective measures. First, self-report questionnaires tend to measure stable differences in the ways in which individuals perceive the world and respond to it (i.e., traits). This measurement approach is reliant on individuals having insight into their own feelings, thoughts, and behaviors related to the construct of interest. In contrast, the P3 component of the ERP measures the neural processes that contribute to moment-to-moment reactions (i.e., states). Unlike self-report measures, this measurement approach is believed to capture how an individual actually responds in a situation and not just what they think they would do. These differences in measurement approaches may explain the lack of convergence across methods observed in the present study. If this is true, then other implicit approaches to construct measurement may be more associated with neurophysiological measures. For instance, while alcohol-cue P3 was not associated with explicit alcohol outcome expectancies in the present study, it may be associated with individual differences in implicit expectancies about the consequences of alcohol (see Wiers et al., 2002). Research has reported that explicit and implicit measures of alcohol expectancies are modestly associated and have unique associations with alcohol use (McCarthy & Thompson, 2006; Wiers et al., 2002). An important aim of future

research should be to test the association between P3 response to alcohol cues and implicit alcohol-related expectancies.

Second, the lack of convergence between self-report and neurophysiological approaches to construct measurement may also indicate that the different approaches are capturing discrete constructs. Behavioral disinhibition is a multidimensional trait with multiple, distinct pathways contributing to disinhibited behavior (Newman & Wallace, 1993; Sher & Trull, 1994). While there is evidence that reward hypersensitivity and reduced P3 response to neutral cues are both indicators of behavioral disinhibition (see Iacono et al., 2008), the present findings suggest that they may reflect separate risk factors for excessive and problematic drinking and other externalizing behaviors. Further research is needed to determine whether reward hypersensitivity and reduced P3 elicited by NR-HOT represent distinct risk pathways to externalizing conditions. If they are indeed separate risk factors, an aim for future research will be to identify the mechanism through which these distal risk factors contribute to the development of alcohol problems.

The present findings should be considered in the context of the study's limitations. First, the alcohol problems (e.g., impaired control, continued use despite problems) assessed by the short form of the ESM (Krueger et al., 2007) are considered to be more severe (Dawson, Saha, & Grant, 2010; Proudfoot, Baillie, & Teeson, 2006; Saha, Chou, & Grant, 2006). This restriction in range of alcohol problems may have artificially truncated the range of some study variables, which, in turn, could have constrained the results. Second, the present sample was comprised primarily of young adult college students from a single geographic region meaning our findings may not generalize to more diverse populations. Nonetheless, this age range is highly relevant given the high rates of

alcohol use disorders among this age group (Grant et al., 2006). Lastly, the cross-sectional nature of our data limited our ability to directly test the directionality of the present findings. While longitudinal data is necessary to definitively conclude directionality, it is important to first establish the required associations for mediation before conducting a more resource-intensive longitudinal project.

In summary, the present research provides some evidence consistent with the acquired preparedness model using self-report measures. However, results also suggest that shared method variance accounted for a large proportion of the observed associations in the mediation models, particularly those including neurophysiological variables. Further research is necessary to determine the extent to which common method variances accounts for the acquired preparedness model. Additional research is also necessary to clarify how neural responses to neutral and alcohol cues relate to one another.

Table 1. Multitrait-Multimethod Matrix of general trait risk factors and alcohol-related cognitive processes

| | Self-Report | | ERP | |
|--|--|----|---------------------|-------------------|
| | RS | AE | P3 _{Neu} | P3 _{Alc} |
| Self-Report | | | | |
| Reward Sensitivity (RS) | () <i>c</i> () | | | |
| Alcohol Expectancies (AE) | | | | |
| Event-Related Potential (ERP) | | | | |
| P3 Reactivity to Neutral Cues (P3 _{Neu}) | a <i>f</i> <i>e</i> b | | () <i>d</i> () | |
| P3 Reactivity to Alcohol Cues (P3 _{Alc}) | | | | |

Note. The single-line boxes are the monomethod blocks, whereas the double-line box is the cross-method block. Letters in boldface type (i.e., a and b) represents the cross-method convergence of indicators of the same trait. Italicized letters within the single-line boxes (i.e., c and d) represent the correlations between general trait risk factors and alcohol-related cognitive processes assessed using the same method. Italicized letters within the double-line box (i.e., e and f) represent the correlations between general risk factors and cognitive processes assessed using different methods.

Table 2. Descriptive statistics for demographic and alcohol use variables

| Variable | Male (<i>N</i> = 60) | Female (<i>N</i> = 95) |
|-----------------------------------|-----------------------|-------------------------|
| | % | % |
| Age | | |
| ≥ 21 years old | 58.3 | 66.3 |
| Race | | |
| Caucasian | 90.0 | 85.3 |
| African-American | 6.7 | 8.4 |
| Asian/Pacific Islander | 0.0 | 5.3 |
| Bi-racial | 1.7 | 1.1 |
| Ethnicity | | |
| Hispanic | 6.9 | 4.2 |
| Education | | |
| High school diploma/GED | 15.3 | 7.4 |
| Some College | 52.5 | 58.9 |
| College degree | 32.2 | 33.6 |
| Drinking frequency | | |
| Never | 1.7 | 3.2 |
| Once a month or less | 23.3 | 22.1 |
| Two or three times a month | 20.0 | 16.8 |
| Once or twice a week | 36.7 | 44.2 |
| Almost daily | 18.3 | 13.7 |
| Drinking quantity | | |
| 1 to 2 drinks | 23.3 | 41.1 |
| 3 to 6 drinks | 53.3 | 47.4 |
| 7 to 11 drinks | 15.0 | 8.4 |
| More than 11 drinks | 5.0 | 0.0 |
| Heavy episodic drinking frequency | | |
| Never | 16.7 | 13.7 |
| Once a month or less | 35.0 | 48.4 |
| Two or three times a month | 13.3 | 11.6 |
| Once or twice a week | 23.3 | 21.1 |
| Almost daily | 11.7 | 5.3 |

Table 3. Correlations and means of self-report and neurophysiological measures of distal and proximal risk factors

| | 1 | 2 | 3 | 4 | 5 |
|----------------------------|------------------|--------|-------|------|------------------|
| Self-Report | | | | | |
| 1. Reward Sensitivity | - | | | | |
| 2. Positive Expectancies | .32*** | - | | | |
| 3. Negative Expectancies | .21* | .24** | - | | |
| P3 Reactivity | | | | | |
| 4. NR-HOT | .01 | .09 | .11 | | - |
| 5. Alcohol-Cue | .14 [†] | .11 | .03 | | .32*** |
| Alcohol Involvement | | | | | |
| Frequency | .22*** | .27*** | -.11 | .00 | .18* |
| Quantity | .36*** | .30*** | .08 | -.01 | -.01 |
| Consequences | .10 | .08 | .25** | -.01 | .15 [†] |
| Substance Use Problems | .22** | .25** | .08 | -.11 | .05 |
| Antisocial Behavior | .45*** | .22** | .18* | -.07 | .01 |
| <i>Mean</i> | 0.53 | 2.92 | 2.50 | 7.65 | 5.28 |
| <i>Standard Deviation</i> | 0.18 | 0.46 | 0.43 | 3.71 | 3.60 |

Note: NR-HOT = Normal/Rotated-Head Oddball Targets

[†] $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

Table 4. Indirect effect estimates for tests of mediation through alcohol-related cognitive processes

| Variable | Alcohol Use Problems | | Substance Use Problems | | Antisocial Behaviors | |
|---------------------------|----------------------|------|------------------------|------|----------------------|------|
| | β | (SE) | β | (SE) | β | (SE) |
| Reward Sensitivity | | | | | | |
| Neg. Alcohol Expectancies | 0.06** | 0.02 | 0.02 | 0.02 | 0.04† | 0.02 |
| Alcohol-Cue P3 | 0.02 | 0.02 | 0.01 | 0.01 | 0.00 | 0.01 |
| | Drinking Frequency | | Substance Use Problems | | Antisocial Behaviors | |
| | β | (SE) | β | (SE) | B | (SE) |
| Reward Sensitivity | | | | | | |
| Pos. Alcohol Expectancies | 0.07* | 0.03 | 0.07** | 0.02 | 0.03 | 0.02 |
| Alcohol-Cue P3 | 0.02 | 0.02 | 0.01 | 0.01 | 0.00 | 0.01 |
| | Drinking Quantity | | Substance Use Problems | | Antisocial Behaviors | |
| | β | (SE) | β | (SE) | β | (SE) |
| Reward Sensitivity | | | | | | |
| Pos. Alcohol Expectancies | 0.05 | 0.04 | 0.06* | 0.02 | 0.01 | 0.02 |

Note: SE = standard error

† $p < .10$, * $p < .05$, ** $p < .01$

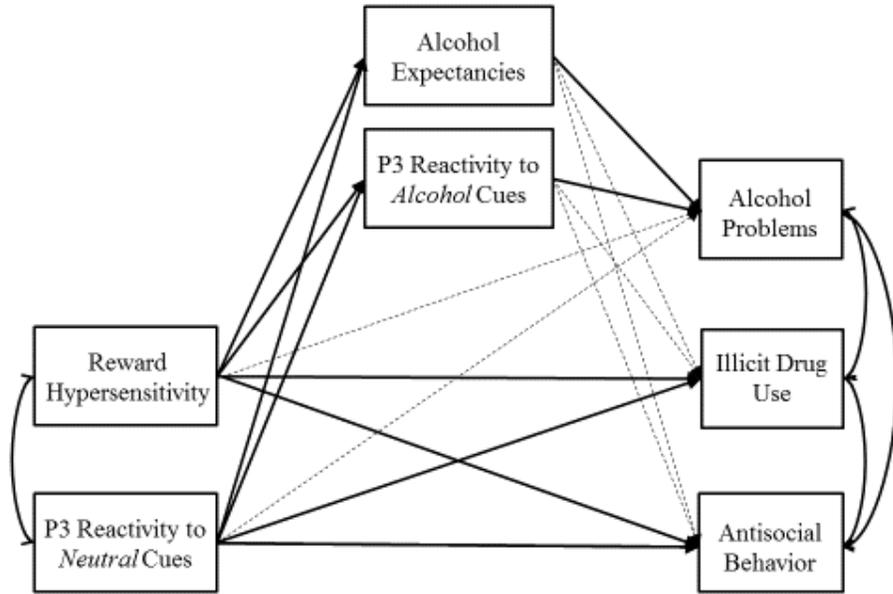


Figure 1. Depiction of the planned mediation model for the effects of general and alcohol-specific risk factors on externalizing problems. Hypothesized non-significant paths are denoted by dashed lines. The effects of drinking frequency/quantity and gender on externalizing problems will be controlled for in the model. Covariates are not depicted to reduce the complexity of the model

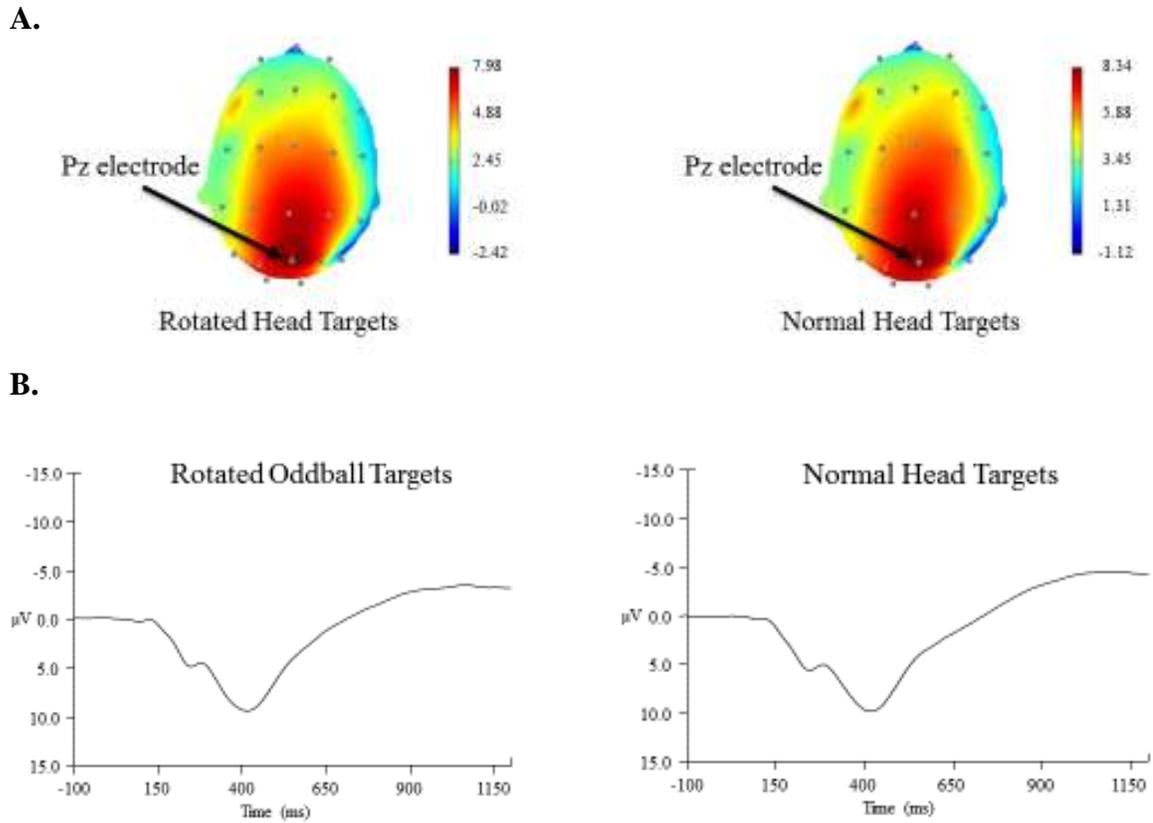
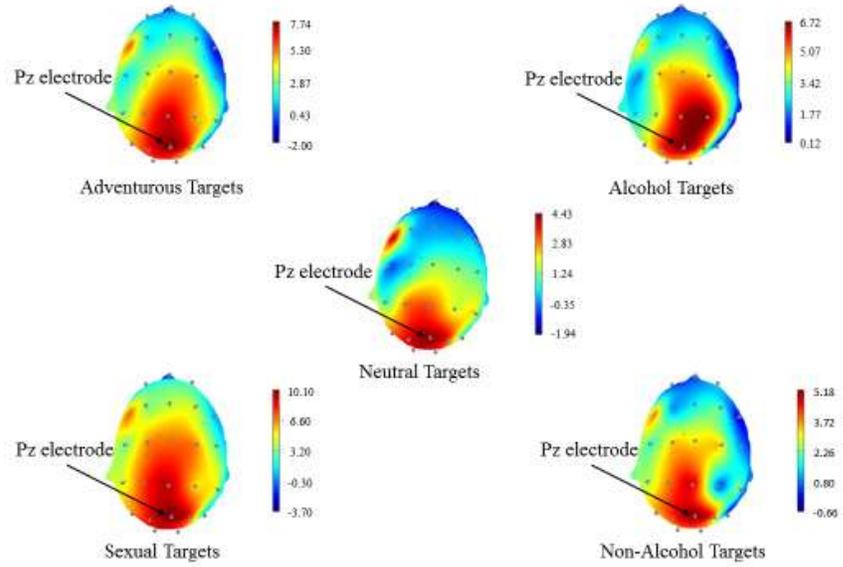


Figure 2. (A.) Topographic maps of the scalp voltage during the time window of the P3 component for normal- and rotated-head targets of the rotated head task. (B.) Stimulus-locked event-related potential (ERP) waveforms elicited at the Pz electrode by each of the target types

A.



B.

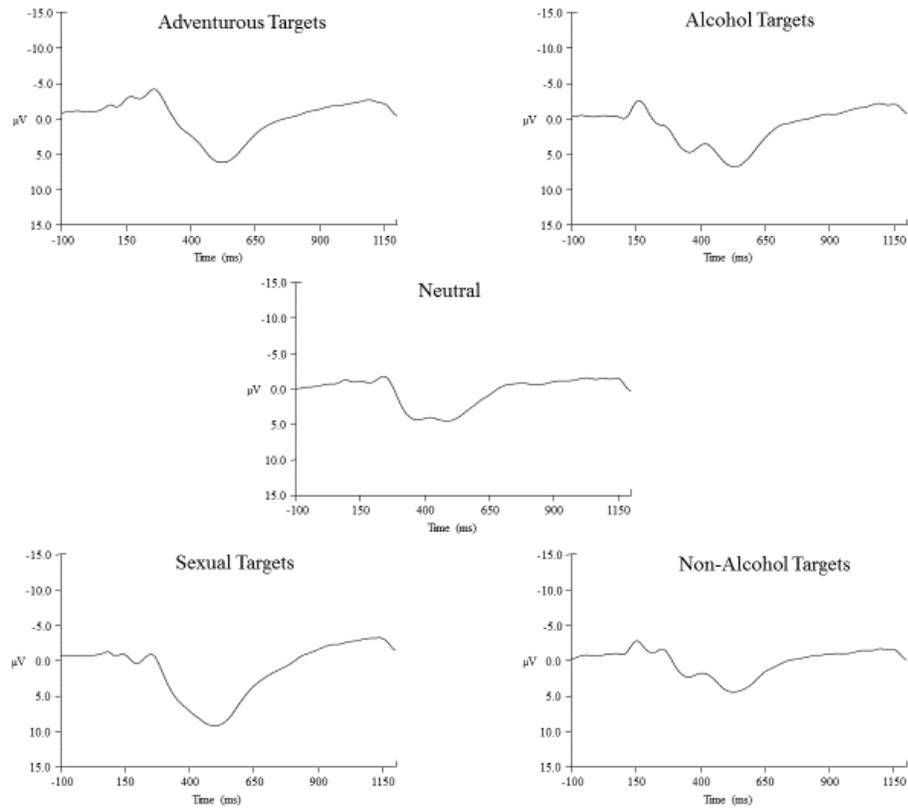


Figure 3. (A.) Topographic maps of scalp voltage during the P3 time window for each of the 5 target types of the picture viewing task. (B.) Stimulus-locked event-related potential (ERP) waveforms elicited at the Pz electrode by each of the 5 target types.

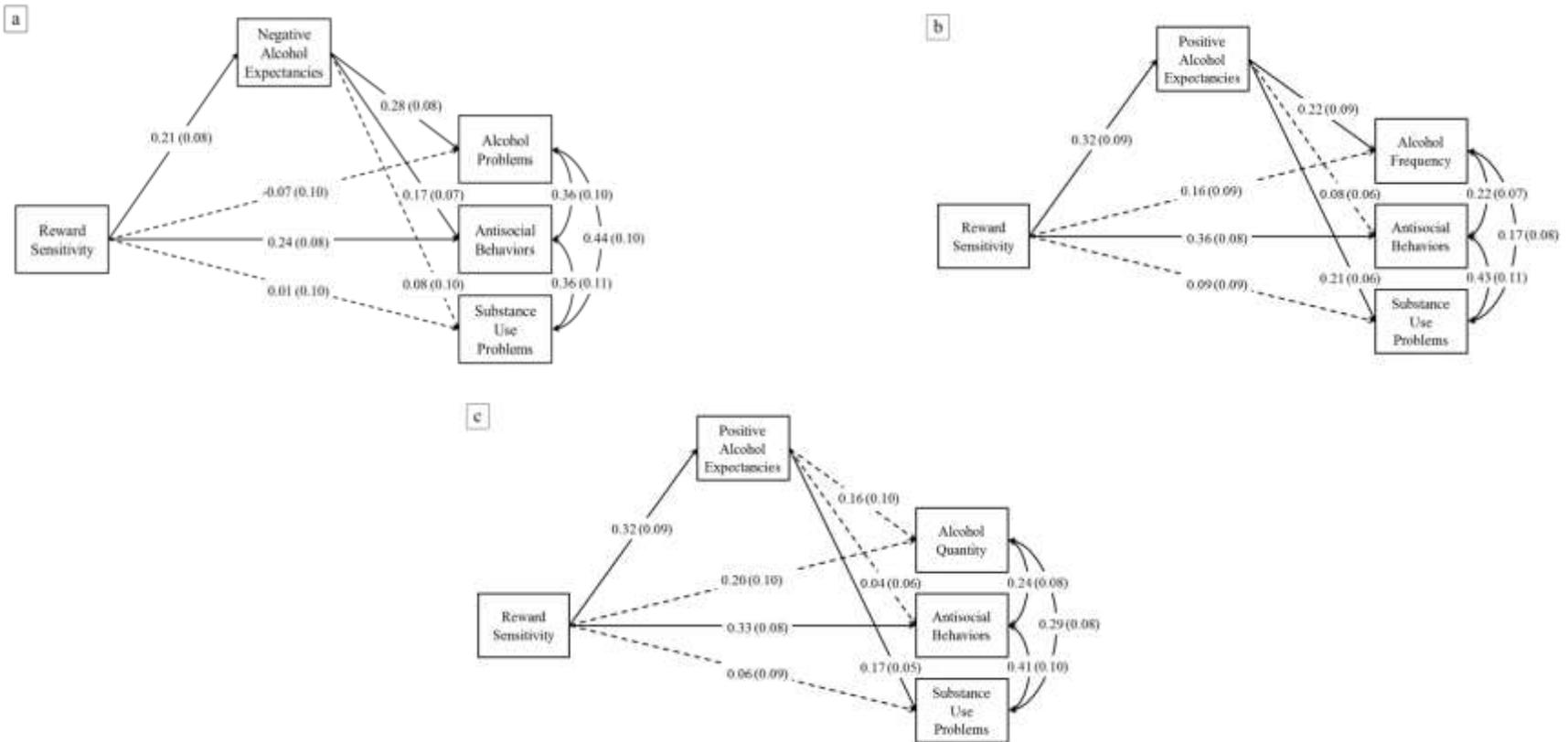


Figure 4. Standardized path coefficients for significant mediation models for reward sensitivity through alcohol outcome expectancies on externalizing conditions. Statistically significant paths are denoted by solid lines ($ps < .001$), and nonsignificant paths are denoted by dashed lines. Covariates (i.e., sex, typical drinking frequency, and typical drinking quantity) were included in all models as predictors of externalizing conditions. For ease of presentation, these paths are not shown.

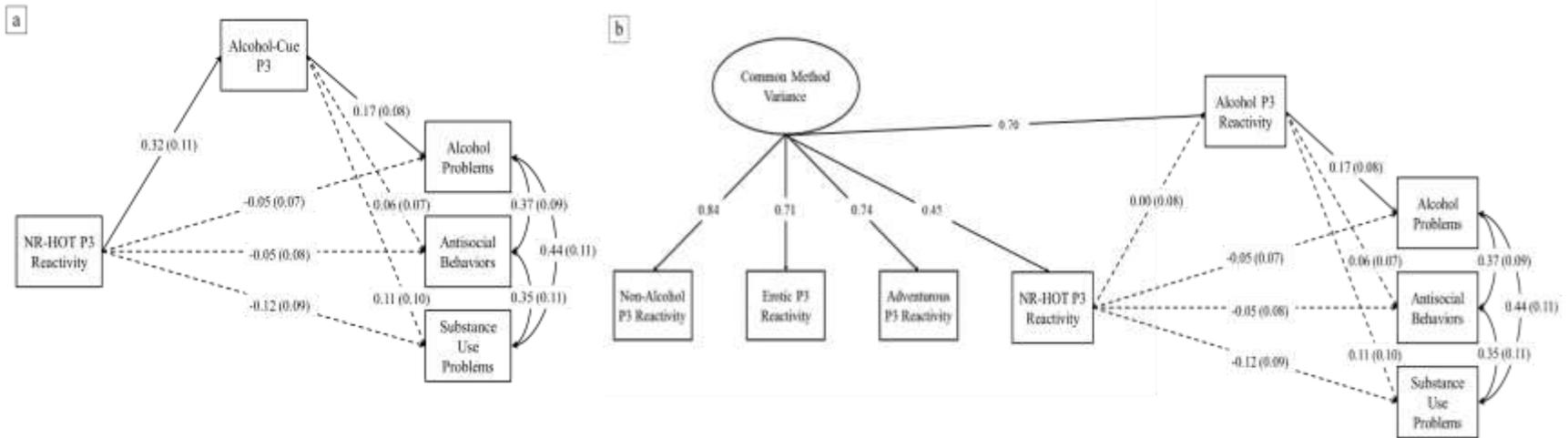


Figure 5. Mediation pathways from P3 elicited by neutral cues to alcohol problems through alcohol-cue P3 with and without controlling for common method variance. Circles reflect latent variables and squares reflect measured variables. Standardized path coefficients are reported. Statistically significant paths are denoted by solid lines ($ps < .001$). Nonsignificant paths are denoted by dashed lines. Covariates (i.e., sex, typical drinking frequency, and typical drinking quantity) were included in both models as predictors of externalizing conditions. For ease of presentation, these paths are not shown. NR-HOT = Normal/Rotated-Head Oddball Targets

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