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Positive Alcohol Expectancies Mediate the Influence of the Behavioral Activation System on Alcohol Use: A Prospective Path Analysis

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Abstract

Gray's (1975, 1987) behavioral activation (BAS) and behavioral inhibition systems (BIS) are thought to underlie sensitivity to reinforcement and punishment, respectively. Consistent with Gray's theory and the Acquired Preparedness model, BAS may facilitate the learning of positive alcohol expectancies (PAEs) over time, leading to increases in drinking. Yet, no prospective tests of this pathway have been reported. The present study investigated whether BAS prospectively predicted PAEs and whether PAEs mediated the association between BAS and subsequent alcohol use. We hypothesized that BAS would influence drinking specifically via enhancement-related PAEs. We also explored the role of BIS in PAEs and drinking. College students (N=557) completed online BAS, PAE, and alcohol use measures in September of their first (T1), second (T2), and third (T3) years of college. We conducted autoregressive path analyses with three BAS subscales and BIS (T1) as predictors, four PAE types (T2) as mediators, and quantity and frequency of drinking (T3) as outcomes. The BAS Fun-Seeking scale was prospectively associated with PAEs, and there was a significant indirect path from Fun-Seeking to alcohol use mediated specifically through activity enhancement PAEs. BIS was positively associated with some PAE types, but did not have indirect effects on drinking. Findings are consistent with both the theory of the BAS and the Acquired Preparedness model, as individuals high on BAS Fun-Seeking may find the rewarding properties of alcohol more reinforcing, leading to stronger enhancement PAEs and increased drinking over time. The prospective design helps establish the temporal association between BAS and alcohol-related learning, and points to the need for prevention efforts that target these at-risk students.

Keywords

behavioral activation system; behavioral inhibition system; alcohol expectancies; alcohol use; longitudinal data

1. Introduction

Heavy alcohol use is a major concern on college campuses (Wechsler & Nelson, 2008). College is a time when alcohol use typically escalates and new drinking habits are formed

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(Arnett, 2005; LaBrie, Lamb, & Pedersen, 2008), and so identifying factors that predict alcohol consumption can aid in the early recognition of at-risk students. Personality traits are among the factors shown to predict alcohol involvement (see Sher, Trull, Bartholow, & Vieth, 1999). Gray's (1987) reinforcement sensitivity is a biologically based model of personality that has linked individual-level traits to drinking outcomes. Importantly, this theory is explicitly learning-based, and thus is directly relevant to understanding learning processes related to alcohol and other substances. Using data from the first three years of college, we examined whether a specific dimension of Gray's model – the behavioral activation system – predicted subsequent student alcohol use through its influence on positive alcohol expectancies.

1.1 Reinforcement Sensitivity Theory and Alcohol-Related Learning

Gray's (1975, 1987) reinforcement sensitivity theory describes two main biologically-based temperament systems that are oriented around reinforcement and punishment: the behavioral activation system (BAS) and the behavioral inhibition system (BIS). Individuals with a strong BAS are thought to be sensitive to reward and respond with greater approach behavior and positive emotion, whereas individuals with a strong BIS are sensitive to punishment and prone to avoidance and negative affect (Corr, 2008; Gray, 1987). BAS is similar to personality traits such as impulsivity, sensation-seeking, and positive urgency – all of which have been linked with alcohol use (e.g., Finn, Sharkansky, Brandt, & Turcotte, 2000; Darkes, Greenbaum, & Goldman, 2004; Fu, Ko, Wu, Cheng, & Settles, 2007; Cyders, & Smith, 2010). Yet, several empirical studies have found that BAS is distinct from related constructs (Cyders et al., 2007; Quilty & Oakman, 2004; Smillie, Pickering, & Jackson, 2006). Namely, BAS is a reward sensitivity and approach motivation construct, whereas these other traits all contain conceptually distinct facets such as disinhibition and behavioral dysregulation, which are not components of BAS. Thus, BAS sensitivity may best be viewed as a more basic subcomponent of impulsivity (Corr, 2008; Quilty & Oakman, 2004; Smillie, Jackson, & Dalgleish, 2006).

Perhaps because of its clear overlap with traits typically characterized by risk-taking, a growing literature links BAS to alcohol use, including problematic use (e.g., Hundt, Kimbrel, Mitchell, & Nelson-Gray, 2008; Knyazev, 2004; O'Connor & Colder, 2005; Pardo, Aguilar, Molinuevo & Torrubia, 2007). Yet the mechanisms underlying this relationship are unclear. Alcohol-related learning may be one pathway from BAS to drinking. For decades, psychologists have argued that the personality-behavior link can be understood from a learning perspective (e.g., Bandura, 1977; Mischel, 1973). Consistent with this, Gray's theory asserts that the BAS is agentic in the learning of reward-related information (see Smillie, Dalgleish, & Jackson, 2007). Thus, BAS may facilitate alcohol-related learning processes as individuals high on BAS are sensitive to reinforcement and may be especially affected by alcohol's rewarding properties.

The concept of alcohol-related learning is well depicted in the construct of alcohol expectancies. Positive alcohol expectancies (PAEs) are learned beliefs that alcohol use can lead to desirable outcomes, and are robust predictors of drinking (Goldman, Del Boca, & Darkes 1999; Maisto, Carey, & Bradizza, 1999; Stacy, Widaman, & Marlatt, 1990). These beliefs are stored in memory (Goldman et al., 1999; Rather & Goldman, 1994). Many factors affect the learning of alcohol information, and much research has been devoted to understanding those processes involved in shaping PAEs (e.g., Cameron, Stritzke, & Durkin, 2003; Dunn, Lau, & Cruz, 2000). The Acquired Preparedness model (Smith & Anderson, 2001) is one theory that has contributed to this literature by exploring how personality may influence learning of PAEs. According to this model, individuals high on traits such as impulsivity and disinhibition may have a bias for attending to reward-related information, resulting in the selective reinforcement of beliefs about the positive outcomes of drinking.

These beliefs in turn lead to increases in drinking, and at least partially mediate the association between personality and drinking (e.g. McCarthy, Miller, Smith, & Smith, 2001; Settles, et al., 2010; Smith & Anderson, 2001).

Data support this learning pathway forwarded by the Acquired Preparedness model (e.g., Anderson, Smith, & Fischer, 2003; Barnow et al., 2004; Darkes et al., 2004; Finn et al., 2000; McCarthy et al., 2001; Settles et al., 2010). At this juncture, it is important to extend the Acquired Preparedness and other learning models of drinking to incorporate personality constructs that may be of mechanistic significance in alcohol-related learning processes. BAS is such a construct. BAS sensitivity is thought to increase the reinforcement value of rewards (Pickering & Gray, 2001; Smillie et al., 2007; Smith, Williams, Cyders, & Kelley, 2006; Zinbarg & Mohlman, 1998), and thus may play a fundamental role in expectancy learning. Indeed, a strong BAS has been shown to facilitate reward learning in experimental paradigms (Pickering, 2004; Smillie et al., 2007; Smith et al., 2006), in ways that other related constructs (e.g., impulsivity defined more broadly) do not (Smillie et al., 2007). Yet, with only two exceptions (O'Connor & Colder, 2009; Simons, Dvorak, & Lau-Barraco, 2009), the contribution of BAS to alcohol information learning has been largely overlooked.

1.2 Multidimensionality: BAS and PAEs

BAS may be comprised of different components, which are reflected in the multidimensionality of some BAS measures (Corr, 2008). Carver & White's (1994) BAS assessment – the most widely used BAS measure – is comprised of three sub-factors: Drive (perseverance in the pursuit of reward), Reward Responsiveness (positive affect in response to reward), and Fun-Seeking (seeking out new rewards and acting quickly on potential rewards). Corr (2008) argued that the sub-factors of Carver & White's BAS correspond to different stages of reward pursuit. In this view, Drive and Reward Responsiveness serve to maintain motivation early on, and then as the reward becomes more proximal, Fun-Seeking takes over to help the individual to quickly seize a reward when it is within reach. Data show that the three BAS scales relate differentially to alcohol use and problems (Franken, Muris, & Georgieva, 2006; Voigt et al., 2009; see also Smillie, Jackson, & Dalgleish, 2006), with Fun-Seeking providing the most reliable prediction of heavy drinking in college students (O'Connor, Stewart, & Watt, 2009) and young adults in general (Johnson, Turner, & Iwata, 2003). Examining the associations between particular facets of BAS and PAEs will allow for the determination of which sub-component of BAS is most relevant in facilitating alcohol-related learning processes.

PAEs also are multi-dimensional, reflecting the many domains of alcohol's rewarding effects (e.g., Kushner, Sher, Wood, & Wood, 1994). Yet many studies of the mediational role of PAEs do not capture this multi-dimensionality, collapsing across expectancy types (e.g., Finn et al., 2000; McCarthy et al., 2001; Sher, Walitzer, Wood, & Brent, 1991). This precludes examination of the unique influences of personality on specific types of PAEs, which have been found in previous studies (e.g., Darkes et al., 2004). Individuals with a strong BAS may have stronger expectancies that alcohol use can induce euphoria and make activities more fun (enhancement PAEs), and these specific types of PAEs may mediate the BAS-drinking link.

1.3 Aims and Hypotheses

The purpose of this study was to help clarify the mechanisms explaining the relationship between BAS and alcohol use by examining a mediated pathway via PAEs. To do so, we used 3 waves of data collected from a large sample of students transitioning into college – a critical period of risk for initiation or escalation of involvement with alcohol (Arnett, 2005;

LaBrie et al., 2008). We sought to examine unique pathways to alcohol use by modeling subcomponents of BAS and PAEs independently. We forwarded the following hypotheses:

1. The prospective association between BAS and drinking will be mediated by positive alcohol expectancies, consistent with the Acquired Preparedness model (Smith & Anderson, 2001).
2. BAS sensitivity will predict increases in all types of PAEs (enhancement, social, tension reduction), because all pertain to reinforcement learning which is influenced by the BAS. However, activity enhancement and performance enhancement PAEs will be stronger mediators of the BAS-drinking link than the other PAE types because they reflect beliefs about positive reinforcement from alcohol, to which the BAS may be most sensitive.

In contrast to the BAS, the relationship between BIS and drinking is less well studied and extant findings have been mixed and complex (e.g., Hundt et al., 2008; O'Connor et al., 2009; Wardell, O'Connor, Read, & Colder, in press). Because BIS is thought to influence punishment-related learning, its theoretical role in positive alcohol expectancies is less clear. An exploration of the role of BIS in learning risk for drinking is needed. In addition, we sought to examine the unique influence of each BAS scale and BIS on PAEs because past research shows that the BAS scales relate differentially to drinking outcomes. However, given that there is no clear theoretical basis for predicting differential influences of BAS scales on PAEs, we did not forward any specific *a priori* hypotheses regarding the separate BAS scales. See Figure 1 for a conceptual model depicting hypothesized and exploratory pathways.

2. Material and Methods

2.1 Participants

2.1.1 Sample selection—As part of a larger study investigating traumatic stress and substance use, matriculating students at two mid-sized public U.S. universities (Site 1 in the Northeastern U.S. and Site 2 in the Southeastern U.S.) were recruited to participate in a longitudinal, web-based survey. Site 1 is a slightly larger, more urban university than Site 2. Also, in our sample Site 2 had a higher proportion of females and African Americans than Site 1.

Recruitment procedures for this sample have been reported elsewhere (Read, Ouimette, White, Colder, & Farrow, 2011).¹ Briefly, all incoming students 18 to 24 years of age were invited to complete a screening survey prior to their first semester. Consistent with other online studies of matriculating college students (e.g. Larimer, Turner, Mallett, & Geisner, 2004; Neighbors, Geisner, & Lee, 2008), 60% ($N=2003$) participated. From this screening sample, all of the participants meeting traumatic stress criteria ($n=378$) were selected for the longitudinal arm of the study, along with roughly an equal number ($n=314$) of randomly selected control participants who did not meet this criteria.² There were no other selection or exclusion criteria at any stage of recruitment. Emails with a survey link were sent to these students inviting them to participate in the longitudinal portion of the study. Of those who

¹The sample size for the present study differs from that reported in Read et al. (2011). This is because the larger study also included a cohort of matriculating college students from University at Buffalo who were recruited one year earlier than the participants in the present analysis. However, because PAE measures were not administered to participants in this cohort, they were not included in our analyses.

²Participants meeting traumatic stress criteria refer to all of those participants who reported experiencing at least one traumatic event in their lifetime to which they responded with fear, helplessness, or horror (PTSD criteria A1 and A2), and who also endorsed at least one current (past month) symptom in each of the 3 symptom clusters of posttraumatic stress disorder (i.e., minimum of 3 symptoms). Control participants refer to a random selection of participants that did not meet symptom cut-offs (i.e., did not have at least one symptom in each cluster).

were targeted for longitudinal follow-up ($n = 692$), a total of 560 (81% response rate) completed a baseline survey in September of their first year of college (T1). Data from 3 participants were excluded from analyses because evidence indicated haphazard responding to the survey items. Thus, 557 participants ($n = 304$ traumatic stress) were retained in the longitudinal sample.

2.1.2 Demographics—Sixty-seven percent ($n = 375$) of participants were female, and the mean age of participants at T1 was 18.11 years ($SD = 0.45$). Seventy percent were Caucasian ($n = 392$), 12% were African American ($n = 67$), 9% were Asian ($n = 52$), 4% were Hispanic ($n = 24$), and 3% were multi-racial ($n = 19$). Less than 1% did not report ethnicity ($n = 3$). The proportion of participants who drank at least once in the past month was 58% at T1, 56% at T2, and 59% at T3. These rates are similar to past month alcohol use prevalence observed in large, nationally representative samples of college students (Substance Abuse and Mental Health Services Administration, 2002–2006). Of the participants who did not report past month drinking at T1, 25% reported alcohol use at T2 and 35% reported alcohol use at T3. At T1, the means for the alcohol use indices (including non drinkers) were 1.28 ($SD = 1.43$) days per week for frequency and 5.70 ($SD = 9.09$) drinks per week for quantity. Although there is variability in estimates of average alcohol consumption among studies of college students, our estimates were consistent with other reports from large samples of college students (e.g., Geisner, Larimer, & Neighbors, 2004).

2.2 Survey Administration

Participants completed a baseline (T1) assessment in September of their first year of college, and subsequent assessments in September of their 2nd (T2) and 3rd (T3) years of college. Participants were given a one-month window within which to complete each survey. The surveys were the same at each time point, and all questionnaires were administered at all three assessments. Gift cards to local retailers were provided as compensation (\$20 at T1, \$25 at T2, and \$30 at T3). Ninety-two percent of participants ($n = 514$) had complete data at T2, and 91% ($n = 509$) had complete data at T3. Overall, the proportion of missing data was 3.55% across all variables included in the analysis. There were no differences between participants with complete data at all time points ($n = 496$) and those with any missing data ($n = 61$) on age, ethnicity, gender, T1 drinking indices, PAEs, BIS, or BAS Drive or Fun-Seeking ($ps > .05$). Those with missing data were lower on T1 BAS Reward Responsiveness ($M = 3.41$, $SD = 0.43$) than those without missing data ($M = 3.54$, $SD = 0.36$), $t(555) = 2.56$, $p = .011$. Our data analysis procedures allowed us to include participants with missing data (see results), and so all 557 participants were included in the present analyses.

2.3 Measures

2.3.1 Demographics questionnaire—Participants reported on gender, age, ethnicity, living situation, high school GPA, and family income.

2.3.2 BIS/BAS scales (Carver & White, 1994)—This measure assesses the BIS (7 items; e.g., “I worry about making mistakes”) and three sub-factors of the BAS: Drive (4 items; e.g., “When I want something, I usually go all-out to get it”), Fun-Seeking (4 items; e.g., “I crave excitement and new sensations”), and Reward Responsiveness (5 items; e.g., “When I get something I want, I feel excited and energized”). Participants rated items on a 4-point scale (1 = strongly disagree to 4 = strongly agree).

Adequate psychometric properties have been reported for these scales (Carver & White, 1994). In this sample, each scale demonstrated adequate internal consistency (Cronbach's alphas at T1 were .75 for Drive, .72 for Fun-Seeking, .69 for Reward Responsiveness³, and .77 for BIS). Participants' responses on these scales were relatively stable across the three

time points given that the assessments were spaced one year apart (intraclass correlations ranged from .47 to .66). Consistent with our theoretical model, only T1 BIS/BAS scores were examined in this study.

2.3.3 Positive alcohol expectancies—Beliefs about the positive effects of alcohol were assessed with 35 dichotomous (yes/no) items from Kushner et al. (1994). The items comprise 4 subscales: tension reduction (9 items; e.g., “Drinking helps me to relax”), social lubrication (8 items; e.g., “Drinking makes me feel less shy”), activity enhancement (9 items; e.g., “Drinking can be exciting”) and performance enhancement (9 items; e.g., “Drinking makes me more creative”). Cronbach’s alpha for the sub-scales at T1/T2 were .90/.86 for tension reduction, .86/.84 for social lubrication, .82/.83 for activity enhancement, and .76/.85 for performance enhancement. We included T2 PAE measures as mediators in our model, as well as T1 PAEs as control variables.

2.3.4 Alcohol use—Participants who indicated that they had consumed alcohol at least once in the past month completed a measure based on the Daily Drinking Questionnaire (DDQ; Collins, Parks, & Marlatt, 1985), which asked them to report the average number of standard drinks consumed on a typical Monday, Tuesday, Wednesday, etc. in the past 30 days. Respondents were given a standard drink conversion chart including a definition of a standard drink. The number of drinks reported were summed across days to create an average weekly quantity variable. Also, an index of typical weekly frequency of alcohol use was created by counting the number of days on which one or more drinks were reported. Those participants who indicated that they had not consumed alcohol in the past month received values of zero on the frequency and quantity variables. Our model included the drinking variables from all three assessment points.

3. Results

3.1 Descriptives and bivariate associations

Prior to analyses, univariate distributions were examined and screened for outliers. Far outliers (i.e., greater than 3.29 *SD* from the mean and clearly disconnected from the rest of the distribution) were set to 1 value greater than the next most extreme, non-outlying observation (Tabachnick & Fidell, 2007). This resulted in recoding a single outlier on 4 variables (T1 BIS, T1 performance enhancement PAEs, T1 Reward Responsiveness, and T2 alcohol quantity).

Table 1 shows means, standard deviations, and bivariate correlations among all variables. Means and standard deviations for the BAS scales and BIS at T1 were similar to other reports using college student samples (e.g., Carver & White, 1994). Standard deviation estimates suggested a fair amount of variability in these scales (SDs ranged from 0.37 to 0.60 on a 1 to 4 scale). Skewness and kurtosis estimates were low for these variables (−0.15 to −0.86 for skewness; −0.09 to 0.88 for kurtosis), and visual inspection of the histograms suggested that BIS and BAS scales were normally distributed in this sample. The PAE scales also approximated normal distributions with a fair amount of variability, although the performance enhancement scale was positively skewed (3.39 at T1, 4.25 at T2) and kurtotic (13.28 at T1, 20.79 at T2). As is typical in a sample that includes non-drinkers, the alcohol quantity and frequency variables were also positively skewed (range: 1.20 to 3.39) and kurtotic (range: 1.66 to 19.50). Thus, robust full information maximum likelihood estimation

³Although .70 is a widely used cut-off for Cronbach’s alpha, it has been argued that $\alpha \geq .60$ reflects adequate internal consistency for scales with less than 10 items (Loewenthal, 1996).

was used to help correct standard errors for bias that may result from non-normality in the data (Muthén & Muthén, 2007).

Inspection of bivariate correlations (see Table 1) revealed that BAS Drive and Fun-Seeking were significantly correlated with all PAEs and drinking indices at all time points, whereas Reward Responsiveness was largely unrelated to PAEs and alcohol use. All PAE scales showed moderate to strong correlations with alcohol use variables, and strong autocorrelations were observed for PAEs and alcohol use across time.

3.2 Path analysis of BAS, PAEs and alcohol use

Using Mplus version 5.0 (Muthén & Muthén, 2007), we constructed a path model similar to that of Settles et al. (2010) in their longitudinal test of the Acquired Preparedness model. Our model included paths from the three BAS scales and BIS at T1 to the four PAE scales at T2, and from these PAE scales at T2 to frequency and quantity of drinking at T3. Also, we included the direct paths from BAS and BIS at T1 to frequency and quantity at T3 in order to compare these direct paths to the indirect effects through PAEs at T2. To control for autoregressive effects, alcohol variables were modeled at all time points and PAEs were modeled at T1 and T2. The three BAS scales, the BIS scale, and four PAE scales each were modeled as separate manifest variables to test hypotheses about differential effects (see Figure 1). We did not model a higher-order BAS latent variable as the BAS scales are not best conceptualized as indicators of a unidimensional construct (Leone, 2009; Ross, Millis, Bonebright, & Bailley, 2002).

To control for the shared variance among PAEs, we estimated pathways from each T1 PAE scale to all four T2 PAE scales, which allowed us to determine whether BAS scales had effects on unique PAE types. We also estimated paths from T1 alcohol variables to T2 PAEs to examine whether BAS predicted PAEs over and above drinking. Lastly, gender, data collection site, and trauma selection status⁴ were all correlated with baseline variables. So, we included them as covariates by estimating paths from these control variables at T1 to all T2 and T3 variables. However, in order to reduce unnecessary complexity in the model, we trimmed nonsignificant paths if they involved control variables and were not primary paths of interest (i.e., gender, site, trauma status, cross-paths from T1 PAEs to T2 PAEs, and paths from T1 drinking to T2 PAEs). All paths that were of primary interest (i.e., BAS/BIS to alcohol use, BAS/BIS to PAEs, and PAEs to alcohol use) were included in the final model regardless of significance level and were not trimmed. All variables within each time point were allowed to freely covary with one another.

We used full-information maximum likelihood estimation, which includes cases with missing data and uses all available information to calculate estimates. To correct for bias in estimates that might result from the skewness of the alcohol variables, robust maximum likelihood estimation was used (Muthén & Muthén, 2007). Model fit was considered good if the Comparative Fit Index (CFI) and Tucker-Lewis index (TLI) were greater than .95 (Hu & Bentler, 1999), the root mean square error of approximation (RMSEA) was less than .06, and the normed chi-square index (χ^2 / df ratio) was less than 3.0 (Kline, 1998).

After trimming nonsignificant control pathways, we observed good model fit for our final model, $\chi^2(47) = 72.19$, $p = .01$, $\chi^2 / df = 1.54$, TLI = .97, CFI = .99, RMSEA = .03. Figure 2

⁴It is important to note that those students selected for traumatic stress symptoms were higher on baseline measures of BAS, BIS, alcohol expectancies, and frequency of alcohol use than the control participants ($ps < .05$), consistent with the hypotheses of the larger study. Although trauma is not a focus of the present analysis, we wished to retain the traumatic stress participants in our sample given that they contributed to variability in drinking and expectancies. However, to control for any potential confounds that differences on traumatic stress symptoms may introduce, we statistically controlled for trauma status in all of our analyses.

shows the significant paths that were observed in the final model. As shown in Figure 2 the only significant direct path from T1 BAS to T3 alcohol use was a negative path from Reward Responsiveness to typical quantity ($\beta = -.10$, $SE = .05$, $p = .034$). BAS Fun-Seeking at T1 had significant direct effects on both T2 activity enhancement PAEs ($\beta = .11$, $SE = .04$, $p = .009$), and T2 tension reduction PAEs ($\beta = .10$, $SE = .04$, $p = .012$), whereas the other BAS scales had no direct effects on PAEs ($ps > .10$). T1 BIS was a significant, positive predictor of T2 tension reduction ($\beta = .13$, $SE = .04$, $p = .002$), social lubrication ($\beta = .16$, $SE = .04$, $p < .001$), and performance enhancement ($\beta = .12$, $SE = .04$, $p = .001$) PAEs. Of the PAE scales, only activity enhancement significantly predicted subsequent quantity ($\beta = .15$, $SE = .06$, $p = .015$) and frequency ($\beta = .19$, $SE = .06$, $p = .003$) of drinking.⁵ Strong autoregressivity was observed, suggesting that PAEs and drinking remained somewhat stable across time (Figure 2).

3.3 Indirect effects of BAS on alcohol use via PAEs

To examine whether PAEs mediated the association between BAS and alcohol use, bootstrapping was used to generate estimates of indirect effects and bias-corrected confidence intervals. This procedure reduces bias caused by the non-normality in the sampling distribution of indirect effects (Shrout & Bolger, 2002). Also, because all direct paths from T1 BAS and BIS to T3 drinking were included in the model, the indirect effects we estimated are over and above the direct effects of BAS and BIS on alcohol use.

Consistent with hypotheses, we observed significant indirect effects from T1 BAS to T3 alcohol use, mediated through T2 PAEs. In particular, the indirect path from BAS Fun-Seeking to alcohol use via activity enhancement PAEs was significant for both quantity ($B = 0.23$, 95% CI [0.08, 0.53], $\beta = .02$) and frequency ($B = 0.05$, 95% CI [0.02, 0.12], $\beta = .02$) outcomes. Given that the direct paths from Fun-Seeking at T1 to drinking frequency ($\beta = .09$, $SE = .05$, $p = .089$) and quantity ($\beta = .02$, $SE = .04$, $p = .511$) at T3 were not significant, these findings suggest that Fun-Seeking influences drinking only indirectly, via activity enhancement PAEs. None of the specific indirect effects involving the other PAE types or BIS and BAS scales were significant (all 95% CIs contain zero).

Finally, to test our hypothesis that enhancement PAEs would mediate more of the influence of BAS scales on alcohol use, we used bootstrapping to obtain the bias-corrected confidence intervals for the differences among the specific indirect effects (Preacher & Hayes, 2008). We found that the indirect effect from Fun-Seeking to alcohol frequency via activity enhancement PAEs was significantly stronger than the indirect effects via tension reduction ($B_{diff} = .04$, 95% CI [.01, .11]), social lubrication ($B_{diff} = .06$, 95% CI [.02, .13]), and performance enhancement PAEs ($B_{diff} = .29$, 95% CI [.10, .68]). We observed a similar pattern for the indirect effects from Fun-Seeking to alcohol quantity, although activity enhancement PAEs was not a stronger mediator of this association than tension reduction PAEs (95% CI_{diff} contains zero).

4. Discussion

This study is the first longitudinal examination of the mediational role of PAEs in the link between BAS and alcohol use. Using data spanning two years following college

⁵We divided participants into two groups: those who endorsed drinking at T1 versus those who did not. We tested the invariance of the model across these groups by constraining all paths of interest (i.e., BAS/BIS to PAEs and PAEs to alcohol use) to be equal across groups and comparing the model fit with the unconstrained model. Alcohol frequency and quantity at T1 were removed from both models because there was no variance in these variables for the non-drinker group. Because robust maximum likelihood estimation was used, we conducted a scaled chi-square difference test, and found no statistically significant decrement in model fit when paths were constrained to be equal across drinkers and non-drinkers, $\Delta \chi^2(30) = 38.27$, $p = .143$.

matriculation, we found support for our hypothesis that BAS influences alcohol use by facilitating the learning of PAEs, though findings were specific to certain BAS and PAE subtypes. This study contributes to the literature on BAS-related drinking by helping to clarify a mechanism in this association. Consistent with assertions that BAS is fundamental to reward learning (Corr, 2008; Smillie et al., 2007), our data suggest that BAS may facilitate the learning of PAEs.

Our findings align with research that has examined the temporal relationships among personality, PAEs, and alcohol use (see Darkes et al., 2004; Settles et al., 2010). We found a significant indirect effect of T1 BAS Fun-Seeking on T3 alcohol use, mediated through T2 activity enhancement PAEs. Consistent with the Acquired Preparedness model and other learning theories, these findings suggest that personality influences the learning of PAEs as time goes on. Moreover, that drinking was influenced indirectly by Fun-Seeking measured two years prior speaks to its importance as a risk factor that has long-term effects on drinking.

This study extends past research by examining the unique contributions of each of Carver & White's (1994) BAS scales to PAE strength and alcohol use. Although both Fun-Seeking and Drive were associated with alcohol use and PAEs in bivariate analyses, only the Fun-Seeking scale had significant effects in the multivariate context of the path analysis. Specifically, Fun-Seeking was indirectly associated with T3 alcohol use via T2 activity enhancement PAEs. These findings are consistent with research on college students showing that Fun-Seeking accounts for more unique variance in alcohol use than the other BAS scales (O'Connor et al., 2009; Voigt et al., 2009). Perhaps Fun-Seeking is a better predictor of alcohol use because it maps onto a later stage in the reward pursuit process, one which requires quick action to seize rewards that are within reach (Corr, 2008). This tendency may lead individuals to be biased toward focusing on the rewarding outcomes of drinking, thus reinforcing PAEs and increasing drinking.

The other BAS scales are thought to correspond to early stages in the reward pursuit process, which require planning and commitment to reward-seeking strategies (Drive) and positive reactions to achieving sub-goals in reward pursuit (Reward Responsiveness; see Corr, 2008). These scales appear to reflect facets of the BAS that are less conducive than Fun-Seeking to risky drinking. Indeed, we observed a significant negative path from Reward Responsiveness at T1 to alcohol quantity at T3, suggesting that this facet of the BAS may serve as a protective factor. To date, only two studies have examined the relationship between BAS and PAEs (e.g., O'Connor & Colder, 2009; Simons et al., 2009), and these studies did not include Carver & White's measure. The present study is the first to our knowledge to show that the BAS scales relate differentially to PAEs in addition to alcohol use.

Our finding that BAS Fun-Seeking predicted increases in PAEs is consistent with research on the role of traits such as impulsivity and sensation-seeking in shaping PAEs (e.g. Darkes et al., 2004; Fu et al., 2007). Of the three BAS scales, Fun-Seeking has the greatest overlap with impulsivity and sensation seeking because it captures the tendency to act quickly on reward opportunities (Corr, 2008). The findings of the present study augment research on the role of impulsivity in alcohol-related learning processes, suggesting the relevance of a learning-based approach to personality in the prediction of drinking behavior.

Furthermore, by examining separate subtypes of PAEs, we were able to determine which PAEs are most closely associated with BAS sensitivity. We expected the BAS to be associated with all PAEs (enhancement, social, tension reduction) as all pertain to reinforcement learning. Our findings provided partial support for this hypothesis; Fun-

Seeking prospectively predicted unique variance in both activity enhancement and tension reduction PAEs. As the enhancement PAEs reflect beliefs about positive reinforcement from alcohol (e.g., euphoria, excitement, pleasure) we also predicted that they would mediate more of the influence of BAS on alcohol use than the other PAE types. Our data partially supported this hypothesis, as activity enhancement PAEs was the only significant mediator in the model. However, performance enhancement PAEs was not a significant mediator. One possible explanation is that beliefs that alcohol improves cognitive and motor skills – which comprise performance enhancement PAEs – may actually reflect expectancies for relief from withdrawal symptoms, which may be less relevant in a non-clinical college sample. Also, activity enhancement PAEs was only a stronger mediator of the path from Fun-Seeking to drinking than tension reduction PAEs when alcohol frequency was the outcome but not when alcohol quantity was the outcome. Thus, caution is warranted in interpreting activity enhancement PAEs as a unique mediator of the BAS-drinking link.

We had no *a priori* hypothesis about the role of BIS in predicting PAEs. Our exploratory analysis revealed that BIS was a positive predictor of tension reduction, social lubrication, and performance enhancement PAEs. The finding that BIS – a punishment sensitivity system – could serve to influence the reinforcement learning processes that shape PAEs was initially somewhat surprising. Yet, this finding makes some sense when considering evidence that a strong BIS tends to be associated with pervasively high anxiety (Corr, 2008; Smillie, Pickering, & Jackson, 2006). Individuals with high anxiety are at risk for drinking to cope (Cooper, Frone, Russell, & Mudar, 1995; Greeley & Oei, 1999), and thus the tension reducing properties of alcohol may reinforce positive beliefs about drinking (O'Connor et al., 2009; Wardell, O'Connor, Read, & Colder, in press). Perhaps BIS predicted increases in many types of PAEs because they all contain elements of drinking for negative reinforcement reasons, including drinking to reduce general negative affect (tension reduction), drinking to reduce social anxiety (social lubrication) and drinking to reduce performance-related anxiety (performance enhancement). Given that BIS and BAS are separate systems and an individual may be high on both BIS and BAS simultaneously, it is important to recognize that this BIS-related negative reinforcement pathway to PAEs and the BAS-related positive reinforcement pathway to PAEs are separate but not mutually exclusive. However, it is notable that we observed no indirect paths from BIS to drinking in our data, despite the finding that BIS predicted several PAEs. This is the first study to test a prospective pathway between BIS and PAEs, and findings point to avenues for future research, especially as BIS appears to predict increases in PAEs but not in drinking.

There are some limitations to the present study. Although our prospective design allows us to draw conclusions about the temporal associations among BAS, PAEs, and drinking, we must emphasize that these data are nonetheless correlational. Thus, causal inferences cannot be made. Explication of causality will require future experimental work, along with examinations of both expectancy formation and drinking initiation (neither of which were captured in the present analysis). Still, results from quasi-experimental studies demonstrating an association between BAS and the learning of reward-related expectancies in the laboratory (Smillie et al., 2007; Smith et al., 2006; Zinbarg & Mohlman, 1998), together with the results of the current study, help to build a case consistent with the theorized causal mechanisms tested here. A similar issue is that we have not examined reciprocal influences among BAS, PAEs and drinking. There is evidence that both personality (e.g., Quinn, Stappenbeck, & Fromme, 2011) and alcohol expectancies (e.g., Sher, Wood, Wood, & Raskin, 1996) in college students may be influenced by drinking experience. Examination of reciprocal influences was beyond the scope of this study, but remains an important avenue to explore in future research.

Carver and White's (1994) measure is the most widely used assessment of BIS and BAS in the literature (Torrubia, Ávila, & Caseras, 2008). Yet, this measure has been criticized. For example, the interpretation of the BAS scales as reflecting different BAS facets is not the only perspective on Carver & White's measure. Some have argued that a unidimensional BAS is more consistent with Gray's theory (e.g. Cogswell, Alloy, van Dulmen, & Fresco, 2006). The small number of items and the relatively low reliability of the BAS scales observed here and in other studies (e.g., Carver & White, 1994; Cogswell et al., 2006) also are limitations of this measure. Yet, other existing measures of BAS are not without problems (Cogswell et al., 2006; O'Connor, Colder, & Hawk, 2004). Future studies should use more than one measure of BAS (including laboratory-based behavioral measures) to bolster construct validity of the measurement. Also, broader assessment of alcohol use will be important in future work.

A related issue is that the BAS construct is similar to other personality constructs such as sensation-seeking, impulsivity, and positive urgency. Although conceptual distinctions among these constructs have been empirically supported (e.g., Cyders et al., 2007; Quilty & Oakman, 2004; Smillie, Pickering, & Jackson, 2006), the degree to which the effects observed here are specific to BAS remains to be examined and is an important direction for future research. In addition, the expectancy scales of Kushner et al. (1994) are only one measure of PAEs. The enhancement and tension reduction PAEs examined in the current study are relevant to learning models based on BAS and BIS; however, measures with scales reflective arousal and disinhibition PAEs may be particularly relevant to models of BAS- and BIS-related learning. Future studies should attempt to extend the present findings to additional dimensions of PAEs.

Our tests were conducted in a sample of students at college matriculation, a time when drinking escalates and alcohol related learning processes likely are occurring. It is yet unknown whether these findings will generalize to other populations. Because ours was a non-selected sample with respect to problematic drinking, it is not clear whether our findings will be applicable to dependent or treatment-seeking individuals. Similarly, our sample was selected to over-represent individuals with current symptoms of posttraumatic stress disorder, which may limit the generalizability of the findings. Indeed, that BIS was positively associated with most of the PAE types and drinking frequency may be a reflection of the higher levels of anxiety symptomatology in the sample, which could have exaggerated the associations between BIS and PAEs by over-representing coping motivated drinkers (e.g., Cooper et al., 1995). Yet, because trauma status was included as a covariate in our model, the effects of BIS on PAEs were above and beyond the variance that can be attributed to selection based on posttraumatic stress symptoms. Also, our sample was imbalanced with respect to gender and included more females than males, likely due to our selection criteria. Although we included gender as a statistical control in our analyses, relative underrepresentation of men in the study may limit generalizability of the findings.

Finally, the significant indirect effects we observed in this study were relatively weak, which may raise concerns about the practical implications of the findings. However, the indirect effects of Fun-Seeking spanned across a full two years and were significant above and beyond strong autoregressive effects for alcohol use and PAEs. Thus, we believe that the findings are theoretically significant and may have clinical utility as well. Individuals high on Fun-Seeking may be appropriate targets for intervention efforts, as these students may be at greater risk for escalating their drinking over time due to increases in PAEs.

In conclusion, this study contributes to the growing literature on BAS-related drinking by helping to elucidate a mechanism in the BAS-drinking link. Our findings are consistent with the Acquired Preparedness model, providing additional longitudinal support for the notion

that personality influences alcohol-related learning processes over time. Early identification of those most likely to increase their alcohol use over time may enhance college-based prevention efforts.

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Highlights

- We examine prospective relations among temperament systems and alcohol use.
- We model positive alcohol expectancies as mediators.
- Fun-seeking indirectly affects alcohol use via activity enhancement expectancies.
- Other types of expectancies do not mediate the influence of temperament on drinking.
- Behavioral inhibition system predicts increases in several alcohol expectancies.

Figure 1.

Conceptual model of the indirect effects of BAS scales (Reward Responsiveness, Drive and Fun-Seeking) and BIS on alcohol use as mediated by positive alcohol expectancies. Solid arrows represent hypothesized pathways (i.e., from BAS to PAEs and PAEs to alcohol use) and dashed arrows represent exploratory pathways (i.e., from BIS to PAEs). Bolded arrows represent indirect paths that are hypothesized to be stronger than the other indirect effects (i.e., BAS to enhancement PAEs and enhancement PAEs to alcohol use). Control paths and direct paths from BAS to drinking are not shown, although these were tested in our model.

Figure 2.

Final path model with behavioral activation system subscales and behavioral inhibition system at time 1 as predictors, positive alcohol expectancies at time 2 as mediators, and alcohol use indices at time 3 as outcomes. Autoregressive paths for positive alcohol expectancies and alcohol use are estimated. Trauma status and gender are included as control variables. All paths from BAS/BIS to PAEs and alcohol use, and all paths from PAEs to alcohol use, are included in the model, although only paths that were significant at the .05 level are depicted here for simplicity. Indirect effects from Fun-Seeking to alcohol frequency and quantity via activity enhancement PAEs are significant, $ps < .05$.

Table 1
Intercorrelations, Means, and Standard Deviations of BAS Scales, Positive Alcohol Expectancies, and Alcohol Use at Both Time Points

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. DR-1	2.73(0.60)																	
2. FS-1	.49*	2.97(0.59)																
3. RR-1	.43*	.33*	3.52(0.37)															
4. BIS-1	.01	-.14*	.27*	3.07(0.54)														
5. TR-1	.15*	.23*	.05	.05	0.28(0.33)													
6. SL-1	.21*	.22*	.08*	.08	.70*	0.26(0.30)												
7. AE-1	.16*	.28*	.05	-.03	.73*	.68*	0.28(0.28)											
8. PE-1	.14*	.21*	.05	-.08	.47*	.44*	.52*	0.05(0.12)										
9. QU-1	.13*	.22*	-.01	-.10*	.52*	.46*	.61*	.36*	5.70(9.09)									
10. FR-1	.15*	.24*	.02	-.04	.61*	.52*	.64*	.38*	.80*	1.28(1.43)								
11. TR-2	.12*	.22*	.06	.11*	.64*	.53*	.54*	.35*	.40*	.46*	0.26(0.29)							
12. SL-2	.16*	.15*	.06	.15*	.45*	.57*	.47*	.28*	.31*	.38*	.68*	0.23(0.28)						
13. AE-2	.13*	.28*	.09*	.01	.54*	.52*	.68*	.33*	.48*	.52*	.68*	.63*	0.29(0.29)					
14. PE-2	.11*	.14*	.09*	.09*	.32*	.32*	.30*	.42*	.22*	.23*	.44*	.48*	.39*	0.05(.014)				
15. QU-2	.13*	.20*	.02	-.11*	.39*	.39*	.47*	.23*	.68*	.56*	.41*	.32*	.51*	.24*	5.80(9.15)			
16. FR-2	.15*	.19*	.03	-.11*	.40*	.37*	.48*	.23*	.54*	.58*	.42*	.33*	.54*	.23*	.80*	1.26(1.47)		
17. QU-3	.09*	.15*	-.08	-.14*	.32*	.29*	.39*	.18*	.57*	.53*	.30*	.22*	.41*	.12*	.66*	.55*	5.55(8.46)	
18. FR-3	.05*	.17*	-.02	-.12*	.34*	.28*	.38*	.17*	.41*	.50*	.30*	.22*	.41*	.10*	.47*	.54*	.77*	1.31(1.53)

Note. Mean (standard deviation) on diagonal; 1 = Time 1; 2 = Time 2; 3 = Time 3; DR = BAS Drive; FS = BAS Fun-Seeking; RR = BAS Reward Responsiveness; TR = Tension reduction expectancies; SL = Social lubrication expectancies; AE = Activity enhancement expectancies; PE = Performance enhancement expectancies; QU = Typical weekly quantity of alcohol consumption; FR = Typical weekly frequency of alcohol consumption;

*
p < .05.