Behavioral Approach System Moderates the Prospective Association Between the Behavioral Inhibition System and Alcohol Outcomes in College Students*

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ABSTRACT. Objective: Reinforcement sensitivity theory (RST) is a useful framework for understanding alcohol use, including problematic drinking among college students. Although the link between the behavioral approach system (BAS) and drinking is well established, the role of the behavioral inhibition system (BIS) is less well studied, and findings have been mixed. Consistent with RST, the relationship between BIS and problematic drinking may be moderated by BAS, but tests of the BIS × BAS interaction have been scarce. We hypothesized that high BIS would be a risk factor for subsequent problematic drinking in combination with an elevated BAS, whereas BIS would protect against subsequent problematic drinking in the context of low levels of BAS. **Method:** College student drinkers (N = 638; 66% women) at two universities completed online measures of BIS, BAS, alcohol use, and alcohol problems at matriculation (Time 1 [T1]) and again 1 year later (Time 2 [T2]). **Results:** Regression analyses of alcohol use and problems were performed with BIS, BAS, and the BIS × BAS interaction as predictors. The interaction was not statistically significant in cross-sectional models (T1 alcohol outcomes), but it was a significant prospective predictor of T2 alcohol use (marginal) and T2 alcohol problems. Simple slopes analyses revealed that BIS was a positive predictor of T2 alcohol use and problems at high but not low levels of BAS, albeit this effect was less reliable for use. **Conclusions:** Our findings enhance interpretation of RST, demonstrating a complex link between BIS and problematic drinking risk, one that is moderated by BAS. The prospective nature of these associations suggests that, together, BIS and BAS may promote increases in problematic drinking over time, highlighting the need for targeted interventions during the first year of college. (*J. Stud. Alcohol Drugs, 72,* 1028–1036, 2011)

PERSONALITY TRAITS ARE THOUGHT TO BE genetically influenced, emerge early in life, show relative stability, and predict a variety of behaviors (Sher et al., 1999), including problematic drinking (i.e., heavy drinking that is associated with negative consequences). Recently, Gray's (1982) reinforcement sensitivity theory (RST) of personality (see also Corr, 2008) has received growing attention in the substance use literature, in part because it provides trait linkage to positive and negative reinforcement mechanisms of substance use. RST posits that individual differences in personality arise from sensitivities of brain systems that respond to reward and punishment, thereby influencing basic learning, motivational, and emotional processes. Thus, RST has implications for the salience of positive and negative alcohol use outcomes. This makes RST a useful framework for elucidating individual differences in the motivational and emotional processes that promote problematic drinking.

Received: February 1, 2011. Revision: May 12, 2011.

*This research was supported by National Institute on Drug Abuse Grant R01DA018993 (to Jennifer P. Read).

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Reinforcement sensitivity theory and alcohol use: Theory and empirical findings

RST (Corr, 2008; Gray, 1982, 1987; Gray and McNaughton, 2000) describes two major temperament systems that may have particular utility for understanding problematic drinking: the behavioral approach (or activation) system (BAS) and the behavioral inhibition system (BIS). According to RST, the BAS is based in dopaminergic reward circuits in the brain and underlies approach motivation, positive affect, and reinforcement learning processes. Individuals with a strong BAS tend to be impulsive sensation-seekers, reacting to reward-related cues (e.g., alcohol) with increases in positive affect and approach motivation (Corr, 2008; Gray, 1987). Thus, a strong BAS may pose a risk for drinking that is motivated by positive reinforcement. Several recent studies found self-reports of high BAS to be associated with problematic drinking (e.g., Hundt et al., 2008; Knyazev, 2004; O'Connor and Colder, 2005; Pardo et al., 2007).

The BIS, based primarily in the hippocampus and amygdala, is responsible for inhibiting approach behavior and gives rise to emotional distress, particularly anxiety (Corr, 2008; Gray, 1982). Originally, a strong BIS was linked with hypersensitivity to conditioned cues of punishment, causing individuals to be pervasively anxious and fearful (Gray, 1982). However, in their revision of RST, Gray and McNaughton (2000) re-conceptualized the BIS as

a conflict resolution system. The BIS is now viewed as an inhibitory system, activated when reward and punishment are cued simultaneously. The main role of the BIS is to inhibit ongoing behavior in the presence of mixed reward and punishment cues and to promote risk assessment to determine whether approach or avoidance goals should be pursued (see Corr and McNaughton, 2008; Gray and McNaughton, 2000). In personality terms, high-BIS individuals are characterized by high levels of uncertainty and anxiety in response to mixed reward and punishment cues. Consistent with the original RST, high BIS is still associated with trait anxiety and negative affect (Smillie et al., 2006). Thus, in terms of personality traits, both the original and the revised RST suggest that BIS gives rise to anxiety.

It is this trait anxiety associated with high BIS that may be particularly important for understanding the role of BIS in drinking behavior. Anxiety (and negative affect broadly) is associated with coping-related drinking (i.e., drinking alcohol to reduce negative affect), which in turn has been linked with problematic alcohol use (Cooper et al., 1995; Greeley and Oei, 1999). For this reason, some researchers have suggested that BIS may lead to problematic drinking through a negative reinforcement pathway (e.g., O'Connor and Colder, 2005). On the other hand, high BIS sensitivity might also protect against problem drinking. Alcohol use has both desirable (e.g., euphoria, tension reduction) and undesirable (e.g., health risks) outcomes, and therefore may be associated with both reward and punishment cues. Consistent with the revised RST, these mixed cues may generate an approach–avoidance conflict to which individuals high on BIS are likely to respond with anxiety and increased vigilance for threat (see Corr, 2008). The combination of anxiety and attention toward the negative consequences of alcohol use may make it less likely that drinking will be pursued. This hypothesized protective pathway was also supported by the original RST, such that the BIS—as a punishment sensitivity system—should deter hazardous drinking to avoid potentially punishing consequences.

Unlike with BAS, there has been relatively little research on the relationship between BIS and problematic alcohol use. Furthermore, past research has yielded equivocal findings. For example, a few studies found a negative correlation between BIS and alcohol use (e.g., Kimbrel et al., 2007; O'Connor et al., 2009b; Pardo et al., 2007). Conversely, one study found that BIS was positively associated with drug use and other risk-taking behavior (Voigt et al., 2009), and another study reported a positive association between BIS and positive alcohol expectancies (O'Connor et al., 2009a). Moreover, null associations between BIS and drinking behavior have been observed in several studies (e.g., Hundt et al., 2008; Kambouropoulos and Staiger, 2007; Knyazev, 2004; O'Connor and Colder, 2005). The failure to find consistent associations between BIS and problematic drinking may reflect the somewhat conflicting predictions made by RST (i.e., BIS could be either a risk or protective factor). We contend that resolving these conflicting predictions requires the consideration of the interactive effects of BIS and BAS.

Interactive effects of behavioral inhibition system and behavioral approach system on alcohol outcomes

Gray's (1987) original theory purported that the effects of the BIS and BAS on behavior were independent of one another. This view has been challenged with the joint subsystems hypothesis, which contends that BIS and BAS interact to affect behavior (Corr, 2002). A few studies have applied the joint subsystems hypothesis to alcohol use to try to clarify the relationship between BAS and drinking (e.g., Hundt et al., 2008; Kimbrel et al., 2007). These studies predicted that the association between BAS and alcohol use would be attenuated by a strong BIS because sensitivity to punishment cues and associated anxiety should moderate BAS output.

This notion that BIS and BAS have interactive effects also may help to clarify the role of BIS for problematic drinking. In particular, BAS may moderate the association between BIS and alcohol use, helping to elucidate this relationship. This hypothesis follows directly from the revised RST. As noted above, alcohol use has both desirable and undesirable consequences. These opposing outcomes should create an approach–avoidance conflict and thus activate the BIS, with high levels of anxiety as the emotional concomitant. Whether this BIS-related anxiety will lead to drinking may depend on the strength of the BAS. A strong BAS might make the rewarding, anxiolytic effects of alcohol especially salient and thus help to resolve the approach–avoidance conflict in favor of drinking as a way of relieving BIS-related anxiety. Consistent with this perspective are recent findings that BIS is associated with expectancies for negative reinforcement from alcohol but only in impulsive individuals (O'Connor et al., 2009a) and that hazardous drinkers are high on both negative affect and BAS sensitivity (Kambouropoulos and Staiger, 2007). On the other hand, BIS may reduce risk for problematic drinking in the context of low BAS. BIS-related anxiety is associated with hypervigilance to threat cues (Corr, 2008). In the absence of a strong BAS to shift attention toward the rewarding, tension-reducing properties of alcohol, the aversive consequences of drinking should be salient, leading to alcohol avoidance.

There is a paucity of empirical research examining the interactive effects of BIS and BAS on alcohol use. Of the few studies that have considered both BIS and BAS, some examined the unique but not the interactive effects of these systems (e.g., Pardo et al., 2007). Those that have tested the BIS × BAS interaction have not found statistically

significant results (e.g., Hundt et al., 2008; Kimbrel et al., 2007). However, these studies were cross-sectional, and given that learning processes are central to RST, the influence of BIS and BAS on behavior may unfold over time. That is, BIS and BAS sensitivity should influence the degree to which alcohol use is reinforcing or punishing. Over time, alcohol-related learning experiences will repeatedly occur, resulting in increases or decreases in alcohol consumption. Thus, the influence of BIS and BAS on problematic alcohol use may be a process that emerges over time, as alcohol-related learning processes have an opportunity to unfold. Accordingly, a prospective investigation of the interactive effects of BIS and BAS on problematic drinking is needed.

Present study

The present study sought to clarify the relation between BIS and problematic alcohol use by examining BAS as a potential moderator. We also sought to examine the prospective influence of BIS and BAS on problematic alcohol use during a critical period in the development of drinking behavior. The first year of college is an important transitional period when students are solidifying new behavioral patterns as they begin the transition from adolescence to adulthood. This is also a time when young adults are at risk for increasing their drinking, and thus, it is a time when there can be an increase in alcohol-related problems (see Arnett, 2005; LaBrie et al., 2008). Accordingly, alcohol-related learning processes occurring during this period may be important targets of interventions. Thus, we investigated the prospective, interactive effects of BIS and BAS on problematic drinking over the first year of college.

In the present study, we examined BIS, BAS, and alcohol use and problems in a sample of matriculating college students in September of their first year (T1) and again 1 year later (T2). We hypothesized that the prospective association between BIS and alcohol use and problems would be moderated by BAS. We predicted a crossover interaction between BIS and BAS such that the association between BIS and subsequent alcohol use/problems would be positive in the context of high BAS and negative in the context of low BAS.

Because BIS and BAS directly influence learning processes, we wished to examine whether their interactive effects on alcohol outcomes unfold over time. Previous cross-sectional studies have not found statistically significant interactions between BIS and BAS in predicting alcohol outcomes. Thus, we hypothesized that this interactive effect may instead emerge only prospectively because the influence of BIS and BAS on alcohol-related learning processes theoretically should occur over time. We conducted both cross-sectional and longitudinal analyses to compare the static and dynamic effects of the BIS × BAS interaction on problematic drinking.

Method

Participants

Sample selection. All study procedures were approved by the ethics review boards of the participating sites. As part of a larger study investigating trauma and substance use, matriculating students at two mid-sized public U.S. universities (Site 1 in the northeast and Site 2 in the southeast) were recruited in three cohorts to participate in a longitudinal, web-based survey. The first cohort of students was recruited from Site 1 in the fall of 2006, and the second and third cohorts were recruited in the fall of 2007 from Sites 2 and 1, respectively. Participants were recruited and screened during the summer before the fall semester of their freshman year. All incoming students ages 18–24 were contacted and asked about trauma and posttraumatic stress symptoms. From this screened sample (N = 3,254), those meeting traumatic stress criteria and an equal number of control participants were selected to take part in the longitudinal study. Of those targeted for follow-up (n = 1,234), a total of 1,002 (81% response rate) participants (across the three cohorts) completed a baseline survey (Time 1 [T1], September). Data from four participants were dropped from analyses because evidence indicated haphazard response styles. In the present analysis, only those who reported past-month alcohol use were included because we were interested in predicting escalation in use and problems among drinkers. This resulted in a baseline sample of 638 drinkers. Of these participants, 587 (92%) completed the Time 2 (T2) survey 1 year later. We compared participants who had complete data at both time points (n = 560) with participants who were missing data on one or more variables at either time point (n = 78). There were no significant differences in age, ethnicity, gender, data collection site or baseline BIS, BAS, alcohol use, or alcohol problems (all ps > .05), suggesting that data were likely missing at random (Enders, 2010). All 638 participants were retained in the analyses.

Demographics. The mean age of the sample was 18.11 years (SD = 0.44), and 66% (n = 420) of participants were women. Seventy-nine percent were White (n = 503), 6% were African American (n = 38), 8% were Asian (n = 51), 3% were Hispanic (n = 22), 3% were multiracial (n = 19), and less than 1% self-identified as "other" (n = 2). Three participants did not report their ethnicity. Eighty-two percent (n = 526) were recruited from Site 1. Roughly equal numbers of students reported living on campus (n = 308) or at home with family (n = 296), with relatively few students reporting other living arrangements. Mean high school grade point average was 3.61 (SD = 0.37), and the median family income was in the $60,000–$80,000 range. At baseline, participants reported drinking an average of three to four drinks per occasion and reported an average of one drinking occasion per week.

Survey administration

As noted above, surveys were completed online in September of the first (T1) and second (T2) years of college. Participants provided informed consent electronically. They were given a 1-month window within which to complete each survey. Participants were compensated with gift cards to a local retailer in the amounts of $20 and $25 at T1 and T2, respectively.

Measures

Behavioral inhibition system/behavioral approach system scales. This questionnaire (Carver and White, 1994) assesses the behavioral inhibition system (7 items; e.g., "I worry about making mistakes") and three subfactors of the behavioral approach system: 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 ranging from *strongly disagree* to *strongly agree.* A mean score was derived for the BIS scale, and scores on the BAS subfactors were averaged to create a single BAS total scale (see Carver and White, 1994). Adequate psychometric properties have generally been reported for these scales (e.g., Carver and White, 1994; Heubeck et al., 1998). In this sample, the BIS and BAS scales demonstrated adequate internal consistency (Cronbach's α's = .77 and .82, respectively).

Alcohol use. Typical weekly frequency and quantity of alcohol use were assessed for the past month. The frequency question read, "Think of all the times in the past month when you had something to drink. How often have you had some kind of beverage containing alcohol?" Participants responded on a 7-point scale ranging *from never in the past month* to *every day.* The quantity question read, "In the past month, when you were drinking alcohol, how many drinks did you usually have on any ONE occasion?" Response options on an 11-point scale ranged from *did not drink in the past month* to *nine or more total drinks.* The frequency and quantity variables were multiplied to provide a past-month quantity–frequency index.

Alcohol problems. Problems from alcohol use were assessed with the 48-item Young Adult Alcohol Consequences Questionnaire (YAACQ; Read et al., 2006). This measure assesses eight domains of alcohol-related problems: social/interpersonal, academic/occupational, risky behavior, impaired control, poor self-care, diminished self-perception, blackout drinking, and physiological dependence. All domains load on a single higher-order consequence factor (Read et al., 2006). Participants provided *yes* (coded 1) or *no* (coded 0) responses to items, indicating whether they had experienced that problem in the past month. A total alcohol problems score was created by summing responses to all of the items. Cronbach's α for the YAACQ in this sample was .93 at T1 and .95 at T2. A small number of participants (n = 20 at T1; n = 11 at T2) were missing data on alcohol problems because of a technical issue with the survey.

Data analytic plan

Before analyses, variables were screened for outliers. Values greater than 3.29 *SD* from the mean and clearly disconnected from the rest of the distribution were recoded to one unit greater than the next most extreme value (Tabachnick and Fidell, 2007). The alcohol problems distributions deviated slightly from normality at both T1 (skewness = 1.45, kurtosis = 2.27) and T2 (skewness = 2.04, kurtosis = 4.46). Also, histograms revealed a noticeable positive skew in the alcohol use and problems variables. Accordingly, the regression analyses used robust maximum likelihood estimation to correct standard errors for bias that may result from nonnormality.

Descriptive statistics and bivariate associations were examined next, followed by hypothesis testing, which was done using moderated regression analyses in Mplus Version 5.2 (Muthén and Muthén, 2007). All variables were standardized to facilitate interpretation of results. Separate models were run for each of the outcomes: alcohol use and alcohol problems. All models included T1 BIS, T1 BAS, and the T1 BIS × BAS interaction term as predictors. Gender also was entered as a covariate in all models. We ran both cross-sectional and prospective tests to explore whether the interactive effects of BIS and BAS on alcohol outcomes differed when observed statically versus across time. In the cross-sectional models, T1 alcohol use and T1 alcohol problems served as the dependent variables. In the prospective analyses, T2 alcohol use and T2 alcohol problems were the dependent variables, and we included T1 alcohol use/problems as covariates to control for autoregressive effects. BIS × BAS interactions were probed using simple slopes analyses (Aiken and West, 1991), treating BAS as the moderator. Specifically, the models were conditioned at high (mean + 1 *SD*) and low (mean − 1 *SD*) levels of BAS.

To reduce potential bias introduced by missing data, we used full information robust maximum likelihood estimation for our analyses. This approach includes cases with missing data and uses all available information, resulting in less biased estimates than listwise deletion of cases with missing data (Enders, 2010; Muthén and Muthén, 2007).

Results

Descriptives and bivariate associations

See Table 1 for variable descriptives and bivariate correlations. Mean BIS and BAS scores and rates of alcohol use

TABLE 1. Intercorrelations, means, and standard deviations of BIS, BAS, alcohol use, and alcohol problems

Variable	1	2	3	4	5	6	*M*	*SD*
1. BIS-T1	1						3.08	0.53
2. BAS-T1	.08*	1					3.16	0.38
3. ALC-T1	-.15**	.14**	1				12.44	9.42
4. PROBS-T1	.11*	.20**	.48**	1			7.98	7.85
5. ALC-T2	-.07	.10*	.58**	.34**	1		11.97	10.73
6. PROBS-T2	.11**	.18**	.30**	.50**	.57**	1	5.67	7.94

Notes: BIS = behavioral inhibition system; BAS = behavioral approach system; T1 = Time 1; T2 = Time 2; ALC = alcohol use quantity–frequency index; PROBS = alcohol problems.
*$p < .05$; **$p < .01$.

and problems were comparable to those observed in other college samples (e.g., Carver and White, 1994; O'Connor et al., 2009a; Read et al., 2007). As expected, baseline BAS was positively correlated with both alcohol use and problems at both time points. Interestingly, BIS was negatively related to alcohol use at T1 but positively related to alcohol problems at both time points. We also looked at gender differences because men and women tend to differ on both drinking patterns and personality dimensions. In our sample, men reported significantly greater alcohol consumption than women at both time points (ps < .001), although no gender differences were observed for alcohol problems (ps > .796). On average, women had higher scores on the BIS scale than men ($p < .001$), but no gender differences were found for BAS ($p = .069$). Because some gender differences were observed, we included gender as a covariate in our analyses.

Moderation analyses

Cross-sectional models. We first examined the interactive effects of BIS and BAS on alcohol outcomes cross-sectionally. The interaction between T1 BIS and T1 BAS was not a statistically significant predictor of T1 alcohol use (β = -.01, *SE* = .03, $p = .748$, $sr^2 < .001$) or T1 alcohol problems (β = .04, *SE* = .04, $p = .314$, $sr^2 = .002$). Lower-order effects of BIS and BAS were consistent with bivariate associations (see Table 1 for bivariate correlations). BAS was positively associated with both T1 alcohol use (β = .16, *SE* = .04, $p < .001$, $sr^2 = .026$) and T1 alcohol problems (β = .20, *SE* = .04, $p < .001$, $sr^2 = .040$), whereas BIS was negatively associated with T1 alcohol use (β = -.09, *SE* = .04, $p = .033$, $sr^2 = .006$) but positively associated with T1 alcohol problems (β = .11, *SE* = .04, $p = .006$, $sr^2 = .011$).

Prospective prediction of alcohol use. Next, we examined the interactive effects of BIS and BAS prospectively (Table 2). Examination of the first-order effects indicated that BIS and BAS were not statistically significant, unique predictors of T2 alcohol use. However, the interaction term approached statistical significance ($p = .091$). Given our theoretical model, we examined the conditional effects of the BIS at high and low levels of BAS. Consistent with our hypothesis, T1 BIS was a marginally statistically significant, positive predictor of T2 alcohol use when conditioned on high levels of T1 BAS (β = .09, *SE* = .05, $p = .082$, $sr^2 = .004$). However, when conditioned on low levels of T1 BAS, there was not a statistically significant association between T1 BIS and T2 alcohol use (β = -.02, *SE* = .05, $p = .712$, $sr^2 < .001$). Figure 1 presents the simple slopes for the prospective association between BIS and alcohol use.

TABLE 2. Moderated regression analyses predicting (a) T2 alcohol use and (b) T2 alcohol problems from T1 BIS, T1 BAS, and T1 BIS × BAS interaction

Dependent	Predictors	β	*SE* β	sr^2
(a) ALC-T2				
	ALC-T1	.57**	.04	.293
	Gender	.04	.04	.001
	BIS-T1	.04	.04	.001
	BAS-T1	.02	.04	.000
	BIS × BAS-T1	.05†	.03	.002
(b) PROBS-T2				
	PROBS-T1	.49**	.06	.221
	Gender	-.01	.04	.000
	BIS-T1	.05	.04	.003
	BAS-T1	.08*	.04	.005
	BIS × BAS-T1	.09*	.04	.009

Notes: T1 = Time 1; T2 = Time 2; BIS = behavioral inhibition system; BAS = behavioral approach system; ALC = alcohol use quantity–frequency index; PROBS = alcohol-related problems
†$p < .10$; *$p < .05$; **$p < .01$.

Prospective prediction of alcohol problems. See Table 2 for the results of the moderation model with T2 alcohol problems as the outcome. Whereas the first-order effect of BAS was statistically significant, the unique association between BIS and T2 alcohol problems was not. The interaction term between BIS and BAS was statistically significant ($p = .016$). Consistent with findings for alcohol use, T1 BIS was a statistically significant, positive predictor of T2 alcohol problems when conditioned on high levels of T1 BAS (β = .14, *SE* = .06, $p = .015$, $sr^2 = .011$) but was not associated with T2 alcohol problems in the context of low levels of T1 BAS (β = -.04, *SE* = .04, $p = .421$, $sr^2 < .001$; Figure 2).

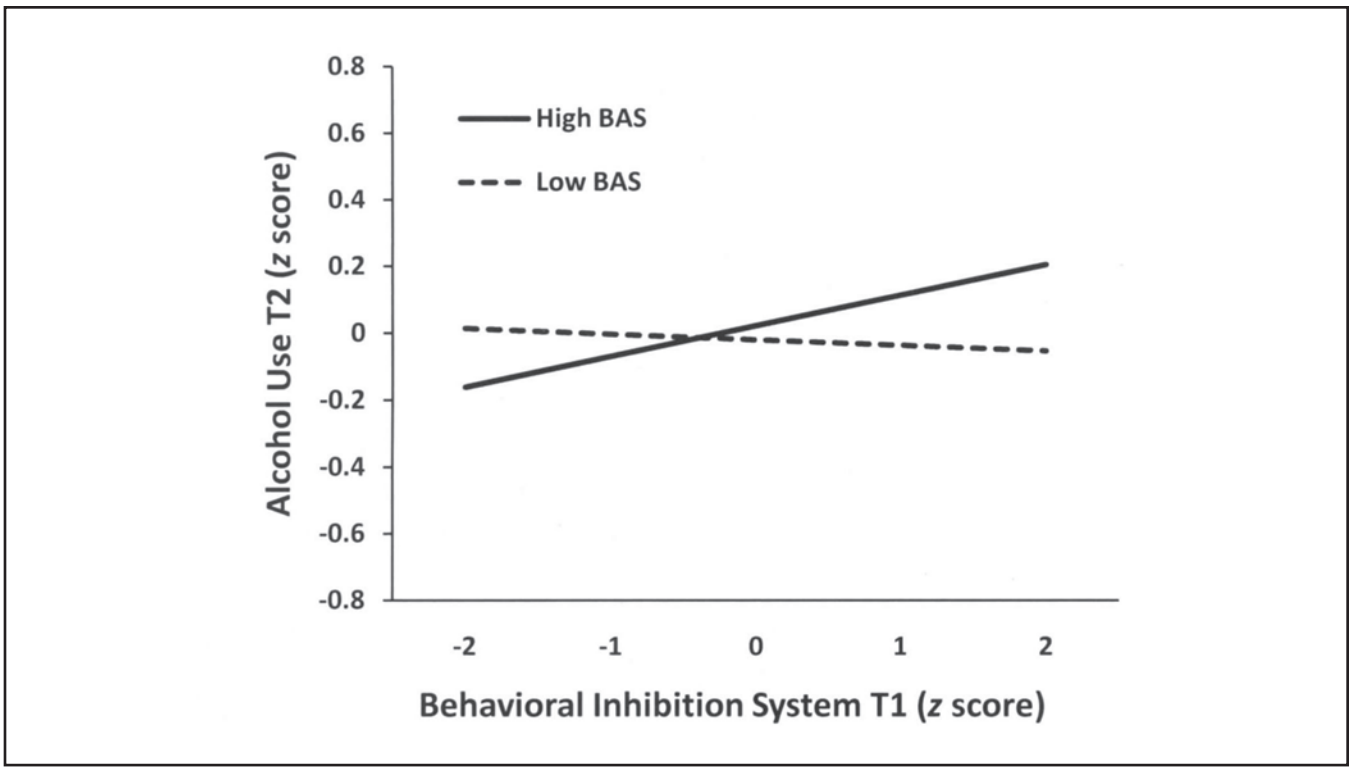

FIGURE 1. Simple slopes for the prospective association between behavioral inhibition system (BIS) and alcohol use at high (mean + 1 *SD*) and low (mean – 1 *SD*) levels of behavioral approach system (BAS)

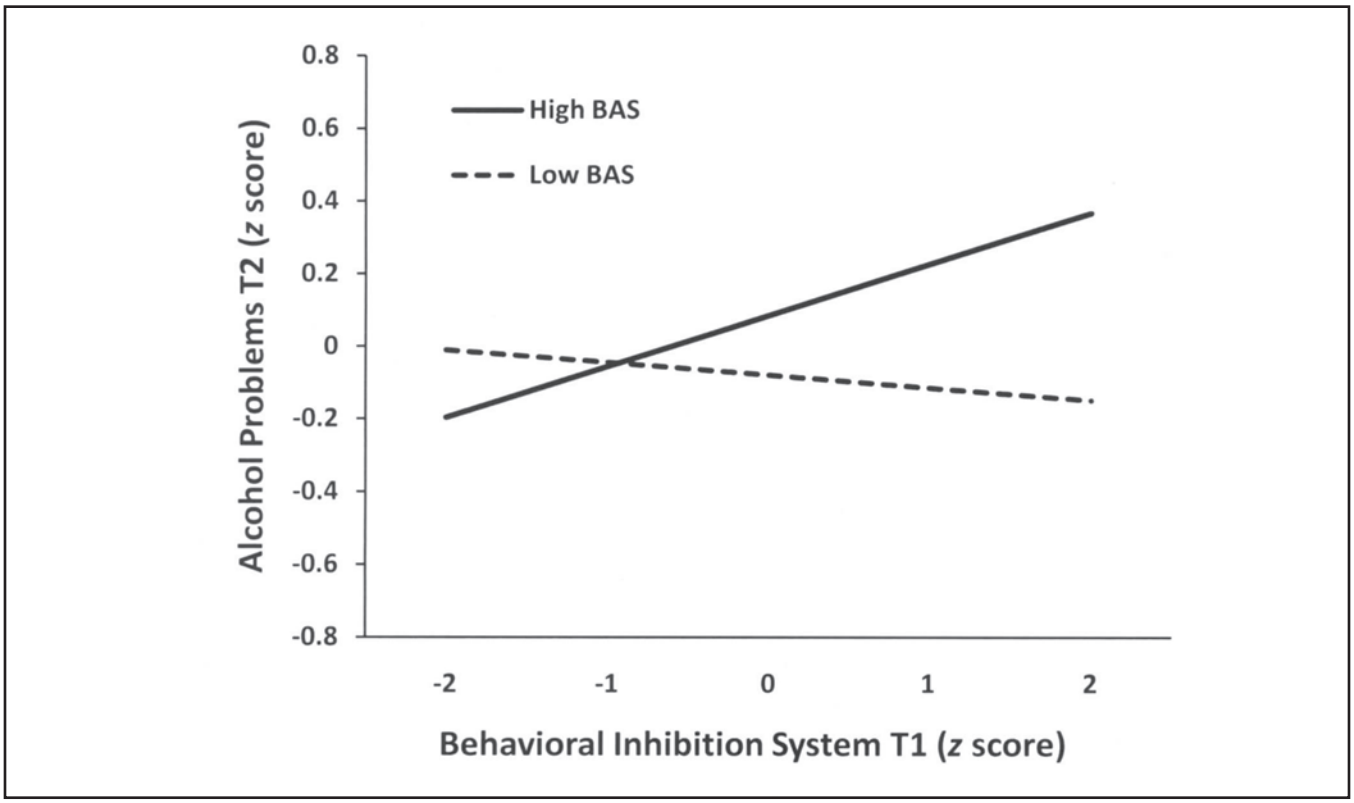

FIGURE 2. Simple slopes for the prospective association between behavioral inhibition system (BIS) and alcohol problems at high (mean + 1 *SD*) and low (mean – 1 *SD*) levels of behavioral approach system (BAS)

Discussion

The present study provides what is to our knowledge the first prospective test of the interactive effects of BIS and BAS on alcohol use and problems. This study contributes to the growing literature on the RST conceptualization of problematic drinking, providing some resolution to the mixed support for BIS as a predictor of drinking behaviors. Although BIS was negatively associated with alcohol use when examined cross-sectionally, we found that high BIS sensitivity, when combined with high BAS sensitivity, placed college students at risk for later alcohol use and alcohol problems in prospective analyses.

Consistent with our hypothesis, self-reported BIS at matriculation was positively associated with increases in both alcohol use (marginally) and problems 1 year later, but only when BAS also was high. It is important to note that—although small in magnitude—the prospective effect of BIS on drinking and alcohol problems emerged over and above the influence of past drinking behavior. However, in the context of low levels of BAS, BIS was not supported as a significant predictor of subsequent alcohol use and problems. This finding helps extend recent theoretical models on the interaction between BIS and BAS (Corr, 2002). Whereas the joint subsystems hypothesis predicts that BAS-related approach behavior may be moderated by BIS, our findings suggest that it is also useful to consider the role of the BAS as a moderator of the association between BIS and drinking behavior.

These results are theoretically consistent with RST and make sense from the perspective of a negative reinforcement pathway to drinking. Individuals high on BIS are prone to anxiety (Corr, 2008), which places them at risk for learning to drink to cope with negative affect (Greeley and Oei, 1999). However, because heavy drinking is associated with both positive (e.g., tension relief) and negative (e.g., health problems) outcomes, it may create an approach–avoidance conflict, to which those high on BIS should be particularly responsive. Accordingly, BIS-related anxiety may be accompanied by vigilance to perceived threat cues, which could deter heavy drinking (see Corr, 2008). Our data suggest that BAS strength is crucial in determining whether BIS-related anxiety promotes or deters problematic drinking. Presence of a strong BAS may help resolve the approach–avoidance conflict by making the rewarding, tension-reducing properties of alcohol especially salient and thus motivating alcohol use. This prediction was supported by our data and aligns with recent findings that the association between BIS and negative reinforcement alcohol expectancies emerges only in the context of high impulsivity (O'Connor et al., 2009a). Our findings also are consistent with data showing that hazardous drinkers are characterized by both high negative affect and high BAS sensitivity (Kambouropoulos and Staiger, 2007). Moreover, we found that BIS was a more reliable predictor of alcohol problems than alcohol use in the context of high BAS. This finding is consistent with past studies showing that a negative affect pathway to drinking is a robust predictor of alcohol problems but only weakly associated with heavy drinking (e.g., Cooper et al., 1995; Merrill and Read, 2010; Read et al., 2003).

We also hypothesized that high BIS sensitivity in combination with a weak BAS would serve as a protective factor against problematic drinking, but this was not supported by our data. According to theory, without a strong BAS to shift the focus to the rewarding properties of alcohol, individuals with a strong BIS should attend to the negative consequences of drinking and avoid alcohol use. Although the associations we observed between BIS and subsequent drinking and alcohol problems were in the negative direction at low levels of BAS, these associations were not statistically significant. However, our sample consisted only of college student drinkers, who may perceive heavy alcohol consumption and associated consequences as being more normative and less harmful than they actually are (Lee et al., 2010; Mallet et al., 2008; Perkins et al., 2005). As such, it is possible that these social norms that are common to the college ethos may allay risk perception of drinking, even for those high on BIS and low on BAS. Perhaps BIS is related to reduced risk for problematic drinking at other life stages. For example, negative drinking outcomes often carry a greater weight in mature adult populations relative to student populations (e.g., there are greater costs to family and careers). Future research with other populations is an important next step in delineating population characteristics that may affect BIS and BAS processes relevant to alcohol use.

It is important to note that Carver and White's (1994) BIS measure, which was used in our study, is based on the original conceptualization of BIS as a punishment sensitivity system. The revised RST not only recast the BIS as a conflict resolution system that responds to mixed reward and punishment cues, but it also clarified the role of a third temperament system, the fight–flight–freeze system (FFFS). According to the revised RST, the FFFS responds to punishment cues and mediates fear and avoidance reactions (Corr, 2008; Gray and McNaughton, 2000). A recent examination of Carver and White's BIS scale found that half of the items loaded on the BIS construct whereas the other half loaded on the FFFS construct (Heym et al., 2008). Thus, we cannot interpret the findings of the present study as a pure reflection of the role of BIS in problematic drinking and must acknowledge that elements of both BIS and FFFS contributed to our results.

Yet, we believe that this limitation does not significantly detract from our findings because Carver and White's measure generally taps into negative affect, which is a central feature of BIS in both the original and revised RST (Corr, 2008). Importantly, it has been argued that Carver and White's BIS scale may be conceptualized from the perspec-

tive of the revised RST as measuring a general "punishment sensitivity" factor at the personality level (Corr and McNaughton, 2008), representing a proneness to general negative affect (such as anxiety and fear). Given that our hypotheses about the association between BIS and drinking outcomes were based primarily on a negative affect pathway to drinking (Cooper et al., 1995; Greeley and Oei, 1999), our use of Carver and White's BIS scale allowed us to measure the essence of negative affect that is pertinent to our model of BIS-related drinking. Nevertheless, future research is needed to disentangle the BIS and FFFS constructs (Gray and McNaughton, 2000). Although some attempts have been made to adapt existing measures of RST traits to be more compatible with the revised RST (e.g., Heym et al., 2008), such adaptations require further validation. Thus, the development of new measures specifically designed to assess BIS and FFFS constructs is an important direction for future work. Furthermore, future studies should attempt to incorporate behavioral measures of BIS and BAS to help bolster construct validity.

A related issue is that the FFFS has been largely ignored in the alcohol literature as well as the broader personality literature. Examining the role of FFFS may be necessary to clarify the possible protective influence of BIS on problematic drinking. According to RST, individuals with a strong FFFS are sensitive to punishment cues (Gray and McNaughton, 2000), and therefore the aversive consequences of drinking should be more salient for these individuals. Thus, a strong FFFS may interact with BIS and help resolve the approach–avoidance conflict in favor of avoiding alcohol use. Future research should examine the FFFS to determine whether, like BAS, it moderates the relationship between BIS and problematic drinking.

Our findings may help to resolve some of the previously reported inconsistencies regarding the BIS–problematic drinking relation. In particular, our data suggest that past findings of a null association between BIS and alcohol use and problems (e.g., Kambouropoulos and Staiger, 2007; Knyazev, 2004; O'Connor and Colder, 2005; Voigt et al., 2009) may be partially explained by a tendency for researchers to overlook the moderating role of BAS. Moreover, previous studies that have examined the interactive effect of BIS and BAS on drinking did not find statistical support for the interaction term (e.g., Hundt et al., 2008; Kimbrel et al., 2007). However, these studies were cross-sectional. Because RST posits that BIS and BAS influence learning processes, their effects on drinking outcomes may emerge over time as individuals have ongoing alcohol-related learning experiences. Our data are consistent with this perspective because the interactive effects of BIS and BAS on alcohol outcomes were not significant when examined cross-sectionally and were only observed in our prospective analyses. Our study also afforded the opportunity to observe these prospective effects in a sample of first-year college students, who are at a crucial period of development with respect to alcohol-related learning (Arnett, 2005; LaBrie et al., 2008). Thus, our data highlight the importance of longitudinal, developmentally appropriate examinations of the role of BIS and BAS in problematic drinking.

Our sample may be unique from other college samples because participants were drawn from a larger study investigating trauma and substance use. Accordingly, the sample was selected to overrepresent students with a history of trauma. Although mean BIS and BAS scores and rates of alcohol use and problems were comparable to unselected college samples reported elsewhere (Carver and White, 1994; O'Connor et al., 2009a; Read et al., 2007), future research should attempt to replicate the present findings with an unselected sample of drinkers. Also, although the first year of college represents an important developmental period to examine predictors of problematic drinking (Arnett, 2005), we examined only students who reported previous experience with alcohol. An important direction for future research is to incorporate the interactive effects of BIS and BAS into a developmental model of alcohol use initiation. This will require an examination of a younger sample because the onset of alcohol use typically occurs in adolescence (Johnston et al., 2002).

The results of the present study suggest potential avenues for targeted prevention efforts because student drinkers who are high on both BIS and BAS at matriculation appear to be at particular risk for escalation of alcohol use and problems over the first year of college. However, the effect sizes observed in the present study were relatively small, and we must use caution in interpreting the practical significance of the findings. Yet, the small effect sizes are to be expected, given that we examined prospective associations among variables measured a full year apart, and we controlled for the strong stability in alcohol use and problems over this time. Moreover, interaction effects in the social sciences generally are small, even in cross-sectional examinations (Cohen et al., 2003). Still, given that observed effect sizes were small, future research is needed to evaluate the potential clinical implications of the findings for targeting prevention efforts toward at-risk students.

In conclusion, our findings suggest that the relation between BIS and problematic drinking is moderated by BAS, such that BIS is positively associated with subsequent drinking and alcohol problems in the context of high levels of BAS. Although we were unable to disentangle the effects of BIS and FFFS when interpreting the results, the findings are consistent with a negative affect pathway to drinking, which is grounded in RST. This study helps to clarify previous inconsistencies in the literature regarding the association between BIS and problematic drinking and highlights the need to consider the interaction between BIS and BAS in drinking behavior. The prospective design of this study advances this literature by highlighting the combined role of BIS and BAS

in alcohol-related learning processes because their effects on problematic drinking appear to emerge over time.

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