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Implicit Alcohol Associations, Especially Drinking Identity, Predict Drinking Over Time

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Abstract

Objective—There is considerable excitement about implicit alcohol associations (IAAs) as predictors of college student hazardous drinking; however, few studies have investigated IAAs prospectively, included multiple assessments, or controlled for previous drinking. Doing so is essential to show their utility as a predictor and, ultimately, target for screening or intervention. Therefore, three IAAs (drinking identity, alcohol approach, alcohol excitement) were evaluated as prospective predictors of drinking in first- and second-year US undergraduates.

Method—A sample of 506 undergraduates completed eight online assessments of IAAs, explicit measures of the IAA constructs, and hazardous drinking (consumption, problems, and risk of alcohol use disorders) every three months over a 21-month period. Retention rates, ordered by follow-up points were 90%, 76%, 76%, 77%, 72%, 67%, and 66%, respectively. Fifty percent of participants were non-drinkers at baseline; 21% were above clinical cutoffs for hazardous drinking.

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Results—Drinking identity and alcohol excitement associations predicted future alcohol consumption and problems after controlling for previous drinking and explicit measures; drinking identity also predicted future risk of alcohol use disorder. Relative to the other IAAs, drinking identity predicted alcohol consumption for the longest duration (i.e., 21 months). Alcohol approach associations rarely predicted variance in drinking.

Conclusions—IAAs vary in their utility as prospective predictors of college student hazardous drinking. Drinking identity and, to a lesser extent, alcohol excitement emerged as robust prospective predictors of hazardous drinking. Intervention and screening efforts could likely benefit from targeting those associations.

Keywords

implicit cognition; alcohol; drinking; drinking identity; IAT

In the early college years, alcohol use is at its peak with young adults not only drinking more frequently, but also drinking more per occasion than any other age group (Naimi et al., 2003) and experiencing a host of negative alcohol-related consequences, including physical and sexual assault, car accidents, poor academic outcomes, and health problems (see Perkins, 2002, for a review). Given these risky behaviors and consequences, identifying additional factors that could be targeted for prevention and intervention efforts is important. Implicit alcohol associations (IAAs; associations about alcohol that are fast, impulsive, and reflexive) are promising factors. They predict drinking in college students (see Reich, Below, & Goldman, 2010), but studies are largely cross-sectional, typically focus on a single IAA and a single outcome variable (i.e., alcohol consumption). Consequently, the predictive validity of multiple IAAs on multiple indicators of college student hazardous drinking is unknown, leaving unanswered questions about whether and/or which IAA(s) should be targeted. The goal of the current study was, therefore, to evaluate three validated IAAs (drinking identity, alcohol approach, and alcohol excitement) as prospective predictors of college students' alcohol consumption, problems, and risk of alcohol use disorders over a period of two academic years.

Implicit Associations as Predictors of College Student Drinking

The surge of interest in IAAs follows from dual process models (Strack & Deutsch, 2004), which focus on the contributions of two types of cognitions on behavior, although it should be noted that dual-process models have been criticized (e.g., De Houwer, 2013), and reformulated to accommodate these criticisms (e.g., Gladwin et al., 2011). According to Strack and Deutsch (2004), explicit cognitions reflect propositional knowledge about constructs (e.g., "Alcohol is exciting") and are accessible (i.e., individuals are aware of them). These cognitions are slower and reflective and are commonly assessed using self-report questionnaires. In contrast, implicit associations are connections between concepts in memory that can be activated automatically (i.e., without conscious control). These associations are thought to be faster and reflexive and are commonly assessed using computer-based reaction time (RT) tasks. The development of computer-based RT tasks in the late 1990's (among others, the Implicit Association Test or IAT, Greenwald, McGhee, & Schwartz, 1998) has enabled greater study of implicit associations. Meta-analyses (see

Greenwald, Poehlman, Uhlmann, & Banaji, 2009) indicate that implicit and explicit measures of the same construct tend to be modestly correlated, and that explicit measures tend to predict with larger effect sizes but both predict unique variance in behaviors.

The IAT has been adapted to study a number of IAAs, including alcohol's effects (reward/relief, arousal/sedation, excite/depress), appetitiveness (approach/avoid), and identity (drinker me/not-me). Studies vary, but IAAs have been found to predict alcohol consumption, alcohol-related problems, risk of alcohol use disorders, and alcohol craving (see Lindgren et al., 2013b; Roefs et al., 2011). Further, cross-sectional findings indicate that IAAs account for unique variance in those drinking outcomes after controlling for explicit measures of the same construct (see Lindgren et al., 2013b; Roefs et al., 2011), suggesting IAAs' inclusion increases the ability to predict important drinking behaviors. Examining predictors of these behaviors during college is particularly valuable because it is such a high-risk period for heavy drinking.

Most IAA studies with college students are cross-sectional studies or single-session lab-based experiments (see Roefs et al., 2011), which leaves unanswered important questions about their utility as prospective predictors of alcohol consumption, problems, and risk of alcohol use disorders. A few short-term longitudinal studies that included college students exist (i.e., with periods ranging from a few weeks to 6 months), and their findings are promising. For example, one study found that alcohol approach associations predicted alcohol consumption six weeks later (Farris, Ostafin, & Palfai, 2010), and a second found that drinking identity associations predicted risky drinking practices six months later (Gray, LaPlante, Bannon, Ambady, & Shaffer, 2011). A study of Dutch college students found that alcohol valence (positive/negative) and arousal (active/sedation) associations predicted alcohol consumption one month later (Wiers et al., 2002). Notwithstanding these important findings, these studies nearly exclusively focused on predicting alcohol consumption; typically measured IAAs only at baseline; usually evaluated only a single IAA; and rarely controlled for previous drinking or explicit measures of the IAA. Controlling for these variables is essential to make the case that IAAs contribute something unique and meaningful in the prediction of college student hazardous drinking. This is especially critical because (computer-based) implicit measures are more resource-intensive than (paper and pencil) explicit measures. We know of no single longitudinal study that has included multiple IAAs and explicit measures of the same constructs and multiple indicators of hazardous drinking and controlled for previous drinking and explicit measures. Not only would such a design allow for tests of the validity for each IAA as predictor of future drinking, but it would also allow for comparisons of each IAA's performance as a predictor relative to the other IAAs.

Previous studies provide guidance about which IAAs to evaluate in such a study. First, drinking identity associations (the extent to which one associates one's self with drinking vs. not drinking) have recently emerged as a robust predictor of college students' alcohol consumption, problems, risk of alcohol use disorders, and craving (Lindgren et al., 2013a, 2013b). Drinking identity also predicted college student risky drinking practices 3- and 6-months later (Gray et al., 2011). Further, there is cross-sectional evidence that it is more consistently associated with consumption, problems, and craving than other IAAs (i.e.,

alcohol approach, alcohol cope, alcohol excite, and alcohol stress associations; Lindgren et al., 2013a; 2013b). Second, alcohol approach associations (the extent to which one associates alcohol with approach vs. avoid) have been found to predict alcohol consumption and risk of alcohol use disorders cross-sectionally (Lindgren et al., 2013a; 2013b), the number of heavy drinking episodes six weeks later (Farris et al., 2010), and drinking in the laboratory when self-control has been depleted (Ostafin, Marlatt, & Greenwald, 2008). Finally, alcohol excitement associations (the extent to which one associates alcohol with excitement or exciting effects vs. depressing effects) were found to be associated with consumption and craving cross-sectionally (Lindgren et al., 2013b) and consumption prospectively (Wiers et al., 2002). Thus, based on their use in the field and their association with alcohol consumption, the drinking identity IAT, the alcohol approach IAT, and the alcohol excitement IAT were included.

Study Goals

Drinking identity, alcohol approach, and alcohol excitement IAAs were investigated in a sample of US undergraduates in their first or second year of college. IAAs, explicit measures of the same constructs, and alcohol consumption, alcohol problems, and risk of alcohol use disorders were assessed at three-month intervals over two academic years. Each IAA was expected to predict greater subsequent drinking (i.e., at the next time point) above and beyond explicit measures and previous drinking. The three IAAs' predictive utility relative to one another was also investigated, including their ability to predict drinking at increasingly longer time periods (i.e., two to seven time points later). Based on previous studies (Lindgren et al., 2013a, 2013b), drinking identity was expected to emerge as the strongest and most consistent predictor of the drinking variables.

Method

Procedures

Study procedures were approved by the university's Institutional Review Board. Participants were recruited via email for a two-year online study of alcohol and cognition (from Fall 2013 through Summer 2015) that included eight assessments every three months. Initial contact information was obtained from the university's registrar's list of full-time students between 18 and 20 years-old in their first or second undergraduate year. Data collection, including informed consent, was online, and participants completed assessments at the computer (and location) of their choice. Assessments that are the focus of this paper consisted of IAA measures and their explicit counterparts and measures of alcohol outcomes (for a full list of measures, please contact the first author). To reduce participant fatigue, IAA measures were evenly interspersed among the explicit measures and alcohol outcome scales. Completion time for each assessment averaged 50 minutes. Four questions to check whether participants were reading self-report items before responding to them were interspersed throughout each assessment; 78% of participants answered them all correctly at T1, 84% at T2, and 90% or more answered them all correctly at the remaining time points. Additional measures unrelated to this study were also interspersed throughout each assessment. Participants received reminders for every assessment: a maximum of 11 emails

and text messages and a maximum of two phone calls. They were paid $25 for the first three assessments; $30 for the last five. As incentives, participants were also paid $5 if they completed all of the first four assessments and $10 for completing the final four. As a final incentive to increase the response rate, shortly before the closure of the final assessment those ineligible for the final bonus were offered an additional $5.

Participants

Participants (N=506; 57% women) were first and second year undergraduates at a large Pacific Northwest public university. Participants were fluent in English and between 18 and 20 years-old (M=18.57, SD=.69). Seven percent classified their ethnicity as Hispanic or Latino and fewer than 1% declined to answer. Fifty-two percent categorized their race as white/Caucasian, 31% as Asian American, 11% as more than one race, 1% as black/African American, 1% as American Indian/Alaska Native, and 4% as unknown or declined to answer. Fifty percent completed all eight assessments. All 506 completed T1, 90% completed T2, 76% completed T3, 76% completed T4, 77% completed T5, 72% completed T6, 67% completed T7, and 66% completed T8. To evaluate possible factors associated with attrition, a variable was created that represented the number of missing assessments, which ranged from 0 to 7; that variable fit a negative binomial distribution. This variable was examined as a function of three sets of baseline variables. First, it was examined as a function of demographics (sex, age, race [White/Caucasian reference], ethnicity). Results revealed no significant associations except that Asian/Asian Americans had fewer missing assessments relative to White/Caucasians ($Z = -4.14$, $p < .001$). Next, missingness was examined as a function of alcohol consumption, problems, and AUDIT scores. Results indicated that only AUDIT scores were positively associated with number of missing assessments ($Z = 2.01$, $p = .04$). Finally, missingness was examined as a function of the three IAAs and the explicit measures of the same constructs. None of the predictors was significantly associated with the number of missing assessments.

Measures and Materials

Implicit Alcohol Associations—The IAT (Greenwald et al., 1998) assesses the relative strength of associations between concepts based on reaction time to classify stimuli into superordinate categories that have been paired to match versus contradict automatic alcohol associations in memory (e.g., associating the self as a drinker vs. non-drinker). Participants are simply asked to classify stimuli into the correct category (e.g., the stimulus “partier” is classified into the “drinker” category) and we examine how quickly that classification occurs when the category label “drinker” has been paired with the category “me” vs. when it is paired the category “not me.” The difference in classification time is thought to reflect the strength of association between the concepts; that is, being faster when “drinker” has been paired with “me” (vs. “not me”) suggests stronger associations consistent with a drinking identity. (As we note below, the IAT is a relative task so associations about being a drinker must always be interpreted relative to associations about being a non-drinker.)

The IATs were web-based, a validated format for measuring IAAs (Houben & Wiers, 2008). Each IAT has seven blocks. Blocks 4 and 7 have 40 trials; the remaining blocks have 20 trials. The drinking identity IAT is used to illustrate the IAT blocks. Blocks 1 and 2 provide

participants with practice classifying stimuli and are not used for scoring the task. For example, in Block 1, participants are asked to categorize stimuli as belonging either to the "me" or "not me" category. The category labels are shown on the top of the screen with "me" on the left and "not me" on the right. Stimuli (words such as "self" or "other") are presented individually on the screen, and participants are asked to categorize using a left key ("e" to categorize the stimulus as a "me" word) and a right key ("i" to categorize a stimulus as a "not me" word). Participants are told to answer quickly and must correct errors to proceed to the next trial. In Block 2, participants are asked to categorize stimuli as belonging to the "drinker" or "non-drinker" category following the same format. Block 3 is a combined block in which all four categories are used. Now, the category labels "me" and "drinker" are shown on the top left of the screen and "not me" and "non-drinker" are on the right. Stimuli from all four categories are randomized and presented one at a time in the center of the screen and participants categorize them using the same left key ("e" to categorize "me" or "drinker" words") and same right key ("i" to categorize "not me" or "non-drinker" words). Block 4 is identical to Block 3 but has more trials (40 vs. 20). Block 5 is a new practice block in which participants categorize stimuli from only one set of categories ("me" and "not me") but their location is switched: "not me" is now on the left and "me" is now on the right. Similar to Blocks 3 and 4, Blocks 6 and 7 contain both sets of categories, but the pairings have changed. Now, "not me" and "drinker" are on the left and "me" and "non-drinker" are on the right. The order of the combined pairings (i.e., "me" paired with "drinker" & "not me" paired with "non-drinker" vs. "me" paired with "non-drinker" & "not me" paired with "drinker") is counterbalanced across participants to minimize order effects.

IAT scores were calculated using the D score algorithm (Greenwald, Nosek, & Banaji, 2003), which is essentially a standardized difference in the average classification time across the combined sets of categories (i.e., the average reaction time for trials in Blocks 3 & 4 subtracted from the average reaction time for trials in Blocks 6 & 7). Each IAT was scored such that higher scores indicated stronger associations with the concepts in the IAT's name. For example, the Drinking Identity IAT was scored such that higher scores indicated being faster at categorizing stimuli when "me" and "drinker" (and "not me" and "non-drinker") were paired than when "not me" and "drinker" (and "me" and "non-drinker") were paired.

Three IATs were used: drinking identity, alcohol approach, and alcohol excitement. Drinking identity IAT (Lindgren et al., 2013b) stimuli included: *drinker*: drinker, partier, drunk, drink; *nondrinker*: nondrinker, abstainer, sober, abstain; *me*: me, my, mine, self; and *not me*: they, them, theirs, other (category labels are italicized). Alcohol approach IAT (Palfai & Ostafin, 2003) stimuli included: *alcohol*: pictures of alcohol; *water*: pictures of water; *approach*: approach, closer, advance; forward, toward; and *avoid*: avoid, away, leave, withdraw, escape. Alcohol excitement IAT (Lindgren et al., 2013b; Wiers et al., 2002) stimuli included: *alcohol*: pictures of alcohol; *water*: pictures of water; *excite*: cheer, fun, high, amplify, excite; and *depress*: sedate, deplete, lessen, depress, quiet. Following Lindgren and colleagues (2013b), the alcohol approach and alcohol excitement IATs were personalized such that participants selected four images of alcohol that best represented the alcohol they consumed most often (non-drinkers were instructed to select the images of the alcohol that they were offered most often); water images were standardized for all participants. The alcohol approach IAT score is thought to be a proxy for how strongly alcohol and approach

(and water and avoid) are associated in memory relative to alcohol and avoid (and water and approach). The alcohol excitement IAT score is thought to be a proxy for how strongly alcohol and excite (and water and depress) are associated in memory relative to alcohol and depress (and water and excite).

Consistent with Nosek and colleagues' recommendations (2007), IAT scores were excluded from analyses if 10% or more trials were faster than 300 milliseconds or if 30% or more trials had errors. *N*'s for excluded T1 IATs were 29 (drinking identity), 20 (alcohol excitement) and 21 (alcohol approach). Across time points, the percentage of excluded IAT scores rarely exceeded 10%. IAT internal consistencies were calculated by creating two D scores (see Greenwald et al., 2003), one from Blocks 3 and 6 and one from Blocks 4 and 7 and correlating them. Internal consistencies were similar to Lindgren and colleagues (2013b), *r*s: drinking identity = .58, alcohol approach = .55, alcohol excitement = .57. Additional information about the reliabilities of the IAT and its maximum correlations with explicit measures and drinking behaviors is provided in an online supplement.

Explicit Drinking Identity—Explicit drinking identity was assessed using the Alcohol Self-concept Scale (Lindgren et al., 2013b). It is a five-item measure in which participants rate their agreement using a 7-point scale (−3 = *strongly disagree* to 3 = *strongly agree*) with statements about how much drinking plays a part in their life and personality (e.g., "Drinking is a part of 'who I am'"). Alpha was .92.

Explicit Alcohol Approach—Explicit alcohol approach was assessed with the inclined/indulgent subscale of the Approach and Avoidance of Alcohol Questionnaire (McEvoy et al., 2004). The subscale includes five items assessing approach inclinations toward alcohol over the past week (e.g., "I would have liked to have a drink or two") and is evaluated with a 9-point scale (0 = *not at all* to 8 = *very strongly*). Alpha was .95.

Explicit Alcohol Excitement—Explicit alcohol excitement was assessed with the enhancement subscale of the Drinking Motives Questionnaire (Cooper, 1994). It has five items that evaluate how much one drinks to increase positive affect (e.g., "Because it gives you a pleasant feeling"). Participants respond using a 5-point scale (1 = *Never/almost never* to 5 = *Almost always/always*) and were instructed to answer "1" if they did not drink. Alpha was .93.

Alcohol Consumption—The Daily Drinking Questionnaire (DDQ: Collins, Parks & Marlatt, 1985) assesses typical alcohol consumption within the past three months. Participants are asked to report how many standard drinks they consumed on each day of a typical week during the last three months. Participants were provided with standard drink equivalencies (12 oz. beer, 10 oz. microbrew beer, 4 oz. wine, 1.5 oz. 80-proof hard liquor).

Alcohol-related Problems—The Rutgers Alcohol Problem Index (RAPI: White & Labouvie, 1989) uses a 5-point scale (0 = *never* to 4 = *more than 10 times*) to evaluate the number of times participants experienced 23 symptoms of problem drinking and negative consequences from drinking in the past three months (e.g., "Suddenly found yourself in a

place that you could not remember getting to"). Two additional items evaluated driving shortly after drinking (see Larimer et al., 2007). Alpha = .91.

Risk for Alcohol Use Disorders—The 10-item Alcohol Use Disorder Identification Test (AUDIT: Babor, Higgins-Biddle, Saunders, & Monteiro, 2001) evaluates risk for alcohol use disorders by assessing consumption, consequences, and symptoms of dependence over the past 12 months. Alpha = .83.

Results

Descriptive Statistics

Throughout the results T1–T8 refer to assessment points Time 1-Time 8, respectively. Correlations, means, and standard deviations for T1 variables are presented in Table 1. The IATs showed mostly small to moderate positive correlations with one another, the explicit measure counterparts, and the alcohol outcomes. The relationship between alcohol excitement and alcohol problems was the sole exception ($r = .09$, $p = .054$). At baseline, 50% of participants reported not drinking; 21% were above cutoffs for hazardous drinking (AUDIT scores ≥ 8).

Data Analytic Plan

Growth models were used to examine how the IAAs predicted drinking at the next time point after controlling for previous drinking and explicit measures of the IAAs. Outcomes (consumption, problems, and risk of alcohol use disorders) were counts (integers greater than or equal to 0) that had a large number of 0 scores. For example, 50% of participants reported no consumption at T1 (dropping to 35% at T4 and 24% at T8), which is consistent with other studies of students in their early college years (cf. Fromme, Corbin, & Kruse, 2009). Thus, zero-inflated negative binomial (ZINB) models were used to model those outcomes.

The ZINB has two parts to the model: the count portion and the inflation portion. The count portion of the model uses negative binomial regression to estimate the expected portion of zeros for a negative binomial distribution with the given mean and dispersion (see Atkins, Baldwin, Zheng, Gallop, & Neighbors, 2013). Exponentiated parameter estimates represent rate ratios, which can be interpreted as the proportional change in the outcome as a function of unit change in the predictor. For example, in the count portion of the model, the drinking identity IAT has an Exp(b) of 1.19 for alcohol consumption, which would equate to drinking 19% more drinks per week for every one-unit increase in the drinking identity IAT. The inflation portion of the model is a logistic regression that predicts excess zeros (i.e., the zeros that exceed the amount expected in a negative binomial distribution). The excess zeros are assumed to be *always* zeros— participants who always abstain from drinking or who never report problems. Parameter estimates from the logistic portion of the model represent log odds of being an *always* zero. Exponentiated coefficients in this portion of the model are odds-ratios. For example, in the logistic portion of the model, the drinking identity IAT has an Exp(b) of .48 for the RAPI, which indicates that for every one-unit increase in the

drinking identity IAT, the odds of never having alcohol problems (i.e., of being an *always* zero) are 0.48 times smaller.

A key issue when analyzing longitudinal data is addressing correlations among repeated observations for individuals. Common analytic choices include multilevel models that use random effects or marginal models that adjust the standard errors of the model parameters to account for within-person correlations (cf. Atkins et al., 2013). Because the subject-specific parameters that are unique to multilevel models (i.e., random effects) were not of primary interest, marginal models with robust standard errors were used (similar to generalized estimating equations; cf. Baldwin, Baldwin, Loehr, Kangas, & Frierson, 2013).

Analyses first focused on each IAA independently as a predictor of drinking outcomes prospectively (i.e., lagged by one time point) and tested whether the IAA predicted variance in those outcomes above and beyond previous drinking and the explicit measure. Each drinking outcome was thus, modeled as a function of sex, time, one lagged IAA variable, the lagged explicit measure of the same IAA construct, and the lagged drinking outcome.

The second phase of the analyses focused on evaluating whether each IAT uniquely predicted a given drinking outcome when controlling for the other IAT variables. Thus, the same growth models were repeated to evaluate whether IAAs prospectively predicted unique variance in drinking outcomes, but models now included all three IATs. Sex, time, and the lagged drinking outcome were again included in the models.

Finally, an exploratory analysis was conducted to evaluate the maximum duration of prediction for each IAT after controlling for lagged drinking and sex. The IATs were evaluated together, beginning with a lag of 2 (i.e., testing T1, T2, T3, T4, T5, and T6 IATs as predictors of T3, T4, T5, T6, T7 and T8 drinking, respectively). This analysis focused on alcohol consumption and was conducted iteratively, increasing the lag at each step, to find the maximum duration of prediction. All models were fit using Stata 13.1 (StataCorp, 2013). The description of results focuses on the performance of the IATs because they are of primary interest.[1]

Evaluating Drinking Identity as a Predictor

Results for analyses evaluating the drinking identity IAT and drinking outcomes are presented in Table 2. The drinking identity IAT was a significant predictor of alcohol consumption on the DDQ and AUDIT scores in the count, but not logistic, portion of the models. Higher scores on the drinking identity IAT prospectively predicted greater consumption and higher AUDIT scores even after controlling for lagged drinking outcomes and the lagged explicit drinking identity measure. The drinking identity IAT was not, however, a significant predictor of the odds of being an always zero for consumption or AUDIT scores. The opposite pattern was found for alcohol-related problems on the RAPI:

[1]All analyses were run with and without participants who missed more than one check question at any time point. The pattern of findings for the IATs and explicit measures of the same IAA construct was identical. Also, the estimated coefficients for all predictors and their resulting p-values were very similar. There was one change in an effect across all analyses: sex became non-significant as a predictor of RAPI scores in the logistic portion of one model if participants were excluded for missing check questions. Thus, given the consistency of the findings, participants were not excluded from analyses in the current study for missing check questions.

Higher drinking identity predicted a lower odds of never having alcohol-related problems (being an always zero), but it did not predict counts.

Evaluating Alcohol Excitement as a Predictor

Results for analyses evaluating the alcohol excitement IAT scores and drinking outcomes are presented in Table 3. The alcohol excitement IAT was a significant (and positive) predictor of alcohol consumption on the DDQ in the count, but not logistic, portion of the model. The opposite pattern was found for RAPI scores; the alcohol excitement IAT was a significant predictor in the logistic, but not count, portion of the model. The alcohol excitement IAT was not a significant predictor of AUDIT scores in either the logistic or count portion of the model.

Evaluating Alcohol Approach as a Predictor

Results for analyses evaluating the alcohol approach IAT scores and drinking outcomes are presented in Table 4. The alcohol approach IAT did not significantly predict consumption on the DDQ, problems on the RAPI, or AUDIT scores in either portion of the models.

Comparing IAAs as Predictors

Results for analyses evaluating the three IATs simultaneously are presented in Table 5. All models again included sex, lagged drinking outcomes, and time as covariates. Explicit measures were not included in these models because IAAs were of primary interest as predictors. Both the drinking identity and alcohol excitement IATs were positive, prospective predictors of alcohol consumption on the DDQ in the count, but not logistic, portions of the model. The alcohol approach IAT predicted consumption on the DDQ in the logistic portion only. The drinking identity and alcohol excitement IATs also significantly predicted alcohol-related problems on the RAPI but in the logistic portion of the model only. Finally, drinking identity was the only significant predictor of AUDIT scores and only in the count portion. Thus, the drinking identity and alcohol excitement IATs made unique contributions as prospective predictors of consumption and RAPI scores, with the drinking identity IAT also contributing to the prediction of future AUDIT scores. In contrast, alcohol approach IAT scores only made a unique contribution as a predictor of the odds of never drinking.

Evaluating Longer-term Predictive Validity

An exploratory analysis examined the IATs' longitudinal predictive validity beyond a single lagged time point. All possible lags predicting drinking were examined, starting with a lag of two time points (i.e., T_{j+2} Drinking = T_j IATs, where j = a given assessment time point. Thus, controlling for previous drinking, Time 3 drinking was predicted from Time 1 IATs; Time 4 drinking was predicted from Time 2 IATs, etc.). Next we increased the lag to three (i.e., T_{j+3} drinking = T_j IATs; assessing whether the IATs can predict 3 time points later) then four through seven (assessing whether the IATs can predict 4 to 7 time points later). In each model, the three IATs, sex, lagged consumption, and predictor time point were included. Results are presented in Table 6. Results for a lag of 2 revealed the same pattern observed with a lag of 1 time point. That is, drinking identity and alcohol excitement IAT

scores were positive predictors of consumption in the count, but not logistic, portion (i.e., they predicted consumption 2 time points out or 6 months later). The alcohol approach IAT scores were significant predictors in the logistic, but not count, portion (i.e., they predicted never drinking 6 months later). The pattern was similar for a lag of 3, but the alcohol excitement IAT dropped out as a significant predictor (and did so for the remaining lags). Drinking identity continued to be a significant predictor in the count portion for lags 4 to 7, indicating that it can predict consumption 4 to 7 time points out (12 to 21 months later). Alcohol approach dropped out as a significant predictor in the logistic portion for a lag of 4, re-emerged for a lag of 5, and dropped out thereafter.

Discussion

This study is the first to include multiple assessments of IAAs and to evaluate them as prospective predictors of multiple indicators of college students' hazardous drinking after controlling for previous drinking outcomes and explicit measures of the same IAAs. As predicted, IAAs were significant predictors of subsequent alcohol consumption, alcohol-related problems, and risk of alcohol use disorders. However, results varied as a function of the specific IAA and the drinking outcome. Drinking identity and alcohol excitement were predictors of later alcohol consumption in the count portion of those models and of later alcohol problems in the logistic portion; that pattern was consistent across models evaluating the IAAs independently or relative to one another. Drinking identity also emerged as a predictor of subsequent risk of alcohol use disorders in the count portion whereas alcohol excitement never predicted it. Moreover, drinking identity out-performed alcohol excitement as a predictor in the exploratory analyses evaluating longer term predictive validity. Both drinking identity and alcohol excitement predicted consumption 6 months later, but only drinking identity continued to be a unique predictor until the end of the study (21 months later). Thus, while both drinking identity and alcohol excitement were unique predictors of consumption and alcohol problems over 3 to 6 month periods, only drinking identity predicted beyond 6 months.

When considering the practical implications of the drinking identity and alcohol excitement findings, both appear to have support as potential targets for college student hazardous drinking prevention or intervention efforts. They contribute uniquely to the prediction of future consumption and alcohol problems, doing so above and beyond explicit measures and previous measures of consumption risk. Assessing drinking identity could be especially useful because of its ability to identify risk across drinking outcomes and for an extended period of time. Use of IATs requires more resources than self-report measures: they take more time to set up, complete, and evaluate, making it important to ensure that they really add to the prediction of prospective drinking in meaningful ways. The results for the drinking identity IAT, and to some extent alcohol excitement IAT, suggest that they do.

The clinical meaningfulness of the alcohol approach findings is less clear relative to the findings with the other IAAs. Essentially, the alcohol approach IAA significantly predicted the odds of never drinking, but not when the explicit measure of alcohol approach was included. Researchers and practitioners would likely be better served by the explicit measure of alcohol approach for college student populations: it is faster and easier to administer and

score and not only predicts the probability of never drinking, but also predicts the full range of drinking (and problems and AUDIT scores). However, the construct should not be dismissed generally, because alcohol-approach tendencies have shown to be an important target for intervention in clinical samples (see Wiers, Gladwin, Hoffman, Salemink, & Ridderinkhof, 2013). Finally, while these findings may seem inconsistent with those from other studies (e.g., Lindgren et al., 2013a; 2013b), zero-order correlations between the alcohol approach IAAs and drinking outcomes were similar across studies. The inconsistencies may reflect differences in design: previous studies were cross-sectional and did not control for baseline or previous drinking.

Limitations and Future Directions

Despite the strengths of the study, the study has several limitations. First, there was some evidence of losing riskier drinkers in later assessments, which may limit the generalizability of findings for those individuals. Second, the internal consistencies of the IATs are similar to those reported in other studies (see Greenwald et al., 2009; Lindgren et al., 2013a; 2013b), which are higher than most latency measures, but considerably lower than most self-report measures, including the explicit measures in this study. Third, it will be important to investigate change in the IAA-drinking behavior relationships and to evaluate lead-lag relationships (i.e., whether changes in drinking lead to changes in IAAs and vice-versa). Evaluating other IAAs, especially those related to valence (i.e., alcohol positive/negative), would also be informative. There were also a large number of non-drinkers in the sample, especially at T1, but note the proportion of non-drinkers in the sample was similar to other studies of early college students (see Fromme et al., 2008) and decreased over time. Finally, the time interval for the AUDIT was one year, which is not ideal for the three-month intervals between assessments.

Conclusions

IAAs predict multiple indicators of college student hazardous drinking over time even after controlling for explicit measures of those IAAs and previous drinking. Drinking identity and alcohol excitement were consistent, significant predictors of consumption and alcohol problems. Given the duration of time over which drinking identity (vs. alcohol excitement) can predict, it appears to be the most robust of the IAAs evaluated and to be a promising target for screening and intervention. Existing evidence-based interventions for college student hazardous drinking might be strengthened by incorporating strategies designed to change drinking identity. Also, recent advances in cognitive bias modification (see Wiers et al., 2013, but also see Lindgren et al., 2015) and mindfulness training (Ostafin, Bauser, & Myxters, 2012) suggest that IAAs themselves can be changed and that doing so may augment treatment efforts.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Baseline Descriptive Statistics and Zero-order Correlations for Study Variables

Variable	1	2	3	4	5	6	7	8	9	10
1. Sex	–									
2. Drinking Identity IAT	−.13**	–								
3. Explicit Identity	−.02	.31***	–							
4. Alcohol Excitement IAT	−.12	.13**	.12*	–						
5. Explicit Excitement	.06	.41***	.46***	.19***	–					
6. Alcohol Approach IAT	−.11**	.22***	.18***	.39***	.28***	–				
7.Explicit Approach	−.01	.46***	.46**	.21***	.76***	.32***	—			
8. Consumption	.00	.38***	.54***	.15**	.51***	.20***	.62***	–		
9. RAPI	.03	.29***	.54***	.09	.49***	.16*	.50***	.61***	–	
10. AUDIT	.01	.44***	.45***	.20***	.68***	.28***	.73***	.79***	.73***	–
Mean	–	−0.08	1.42	−0.10	11.24	−0.21	2.92	5.10	3.00	4.37
Standard Deviation	–	0.45	0.91	0.46	6.21	0.40	2.71	8.54	6.13	5.07

Note. N = 506. Sex was coded 0 = men, women = 1. IAT = Implicit Association Test. IATs were scored such that higher scores indicate stronger associations with the concepts in the IAT's name. Explicit Identity = scores on the alcohol self-concept scale; higher scores indicate stronger drinking identity. Explicit excitement = scores on the enhancement drinking motives subscale; higher scores indicate stronger enhancement motives for drinking. Explicit approach = scores on the inclined/indulgent subscale; higher scores indicate stronger alcohol approach inclinations. Consumption = self-reported number of drinks consumed on a typical week. RAPI = scores on the Rutgers Alcohol Problem Index. AUDIT = scores on the Alcohol Use Disorder Identification Test.

*** $p < .001$.

** $p < .01$.

* $p < .05$.

Table 2

Models Evaluating Implicit and Explicit Drinking Identity as Predictors of Subsequent Drinking Outcomes

	Logistic portion of model			Count portion of model		
	Exp (*b*)	***Z***	***95% CI***	**Exp (*b*)**	***Z***	***95% CI***
DV = Consumption						
Sex	0.71	−1.80	0.49–1.03	0.97	−0.51	0.86–1.10
Previous Consumption	0.18	−5.69***	0.10–0.33	1.07	13.22***	1.06–1.08
Time	0.94	−1.71	0.87–1.01	1.00	−0.20	0.98–1.02
Explicit Identity	0.25	−4.51***	0.13–0.45	1.27	4.32***	1.14–1.42
Identity IAT	0.89	−0.54	0.59–1.35	**1.19**	**2.38***	**1.03–1.37**
DV = RAPI						
Sex	0.64	−2.27*	0.43–0.94	0.93	−0.81	0.78–1.11
Previous RAPI	0.34	−8.25***	0.26–0.44	1.09	11.36***	1.07–1.10
Time	0.89	−2.62**	0.81–0.97	0.98	−0.89	0.95–1.02
Explicit Identity	0.43	−3.72***	0.27–0.67	1.39	3.62***	1.16–1.66
Identity IAT	**0.48**	**−3.16****	**0.30–0.75**	1.12	1.04	0.91–1.38
DV =AUDIT						
Sex	0.76	−1.16	0.48–1.21	0.96	−1.05	0.89–1.04
Previous AUDIT	0.03	−7.33***	0.01–0.08	1.12	14.97***	1.11–1.14
Time	0.98	−0.45	0.89–1.08	1.01	0.76	0.99–1.02
Explicit Identity	0.32	−1.98*	0.11–0.99	1.20	3.90***	1.09–1.31
Identity IAT	1.02	0.05	0.57–1.81	**1.13**	**2.42***	**1.02–1.24**

Note. N = 506. Sex was coded 0 = men, women = 1. Identity IAT = scores on the Implicit Association Test; higher scores indicate stronger drinking identity. Bolded values indicate statistically significant IAT scores. Explicit Identity = scores on the alcohol self-concept scale; higher scores indicate stronger drinking identity. Both the IAT and the explicit measure were lagged; models predict outcomes one time point later. Consumption = self-reported number of drinks consumed on a typical week. RAPI = scores on the Rutgers Alcohol Problem Index. AUDIT = scores on the Alcohol Use Disorder Identification Test. Exp (*b*) = the exponentiated coefficient.

*** $p < .001$.

** $p < .01$.

* $p < .05$

Table 3

Models Evaluating Implicit and Explicit Alcohol Excitement as Predictors of Subsequent Drinking Outcomes

	Logistic portion of model			Count portion of model		
	Exp (*b*)	***Z***	***95% CI***	**Exp (*b*)**	***Z***	***95% CI***
DV = Consumption						
Sex	0.75	−1.53	0.52–1.08	0.92	−1.30	0.82–1.04
Previous Consumption	0.21	−3.57***	0.09–0.50	1.06	12.03***	1.05–1.07
Time	0.94	−1.49	0.86–1.02	0.99	−0.93	0.97–1.01
Explicit Excitement	0.87	−5.27***	0.83–0.92	1.05	6.86***	1.03–1.06
Excitement IAT	0.84	−0.78	0.55–1.29	**1.13**	**2.33***	**1.02–1.25**
DV = RAPI						
Sex	0.78	−1.20	0.51–1.17	0.92	−0.93	0.78–1.09
Previous RAPI	0.35	−7.91***	0.27–0.46	1.09	11.60***	1.07–1.10
Time	0.92	−1.60	0.84–1.02	0.97	−1.92	0.93–1.00
Explicit Excitement	0.89	−5.51***	0.85–0.93	1.03	3.94***	1.02–1.05
Excitement IAT	**0.57**	**−2.40***	**0.37–0.90**	0.91	−0.99	0.76–1.09
DV =AUDIT						
Sex	0.78	−1.06	0.49–1.24	0.92	−2.09*	0.86–1.00
Previous AUDIT	0.03	−5.41***	0.01–0.10	1.10	14.58***	1.09–1.12
Time	0.97	−0.61	0.88–1.07	1.00	−0.38	0.98–1.01
Explicit Excitement	0.92	−1.76	0.84–1.01	1.04	8.68***	1.03–1.05
Excitement IAT	0.73	−1.23	0.45–1.20	1.08	1.94	1.00–1.16

Note. $N = 506$. Sex was coded 0 = men, women = 1. Excitement IAT = scores on the Implicit Association Test; higher scores indicate stronger alcohol excitement associations. Bolded values indicate statistically significant IAT scores. Explicit excitement = scores on the enhancement drinking motives subscale; higher scores indicate stronger enhancement motives for drinking. Both the IAT and the explicit measure were lagged; models predict outcomes one time point later. Consumption = self-reported number of drinks consumed on a typical week. RAPI = scores on the Rutgers Alcohol Problem Index. AUDIT = scores on the Alcohol Use Disorder Identification Test. Exp (*b*) = the exponentiated coefficient.

*** $p < .001$.

** $p < .01$.

* $p < .05$.

Table 4

Models Evaluating Implicit and Explicit Alcohol Approach as Predictors of Subsequent Drinking Outcomes

	Logistic portion of model			Count portion of model		
	Exp (*b*)	***Z***	***95% CI***	**Exp (*b*)**	***Z***	***95% CI***
DV = Consumption						
Sex	0.66	−2.14*	0.45–0.97	0.97	−0.43	0.86–1.10
Previous Consumption	0.19	−2.85**	0.06–0.59	1.06	11.39***	1.05–1.07
Time	0.94	−1.29	0.87–1.03	0.99	−0.91	0.97–1.01
Explicit Approach	0.64	−6.43***	0.56–0.74	1.11	6.85***	1.08–1.15
Approach IAT	0.76	−0.98	0.45–1.31	1.07	0.92	0.92–1.24
DV = RAPI						
Sex	0.67	−1.99*	0.45–0.99	0.99	−0.16	0.83–1.17
Previous RAPI	0.37	−8.11***	0.29–0.47	1.09	11.08***	1.07–1.10
Time	0.92	−1.73	0.84–1.01	0.97	−1.54	0.94–1.01
Explicit Approach	0.74	−5.90***	0.66–0.81	1.09	3.74***	1.04–1.14
Approach IAT	0.70	−1.24	0.40–1.23	0.88	−1.33	0.73–1.06
DV =AUDIT						
Sex	0.76	−1.08	0.47–1.24	0.97	−0.81	0.90–1.05
Previous AUDIT	0.04	−6.44***	0.01–0.10	1.11	15.04***	1.09–1.12
Time	0.94	−1.16	0.84–1.05	1.01	0.98	0.99–1.02
Explicit Approach	0.50	−3.59***	0.34–0.73	1.08	7.90***	1.06–1.11
Approach IAT	1.32	1.00	0.76–2.30	1.03	0.60	0.94–1.13

Note. N = 506. Sex was coded 0 = men, women = 1. Approach IAT = scores on the Implicit Association Test; higher scores indicate stronger alcohol approach associations. Bolded values indicate statistically significant IAT scores. Explicit approach = scores on the inclined/indulgent subscale; higher scores indicate stronger alcohol approach inclinations. Both the IAT and the explicit measure were lagged; models predict outcomes one time point later Consumption = self-reported number of drinks consumed on a typical week. RAPI = scores on the Rutgers Alcohol Problem Index. AUDIT = scores on the Alcohol Use Disorder Identification Test. Exp (*b*) = the exponentiated coefficient.

*** $p < .001$.

** $p < .01$.

* $p < .05$.

Table 5

Models Evaluating All IATs as Predictors of Subsequent Drinking Outcomes

	Logistic portion of model			Count portion of model		
	Exp (*b*)	***Z***	**95% CI**	**Exp (*b*)**	***Z***	***95% CI***
DV = Consumption						
Sex	0.73	−1.62	0.50–1.07	0.95	−0.83	0.83–1.08
Previous Consumption	0.18	−5.29***	0.09–0.34	1.08	15.46***	1.07–1.08
Time	0.96	−1.09	0.89–1.04	0.99	−0.77	0.97–1.01
Identity IAT	0.90	−0.46	0.59–1.38	**1.19**	**2.35***	**1.03–1.37**
Excitement IAT	0.79	−1.00	0.50–1.25	**1.20**	**2.97****	**1.07–1.36**
Approach IAT	**0.54**	**−2.23***	**0.32–0.93**	0.99	−0.07	0.85–1.16
DV = RAPI						
Sex	0.68	−1.91	0.46–1.01	0.95	−0.56	0.80–1.13
Previous RAPI	0.31	−9.47***	0.25–0.40	1.09	12.37***	1.08–1.11
Time	0.88	−2.63**	0.81–0.97	0.98	−0.88	0.95–1.02
Identity IAT	**0.45**	**−3.29****	**0.28–0.72**	1.13	1.11	0.91–1.39
Excitement IAT	**0.55**	**−2.43***	**0.34–0.89**	0.89	−1.18	0.74–1.08
Approach IAT	0.71	−1.22	0.41–1.23	1.05	0.44	0.85–1.30
DV =AUDIT						
Sex	0.84	−0.71	0.52–1.36	0.97	−0.77	0.89–1.05
Previous AUDIT	0.03	−6.31***	0.01–0.09	1.13	16.53***	1.12–1.15
Time	1.00	−0.07	0.90–1.10	1.00	0.43	0.99–1.02
Identity IAT	1.04	0.12	0.56–1.91	**1.12**	**2.18***	**1.01–1.23**
Excitement IAT	0.76	−1.10	0.46–1.25	1.06	1.58	0.99–1.15
Approach IAT	0.94	−0.21	0.51–1.71	1.05	1.04	0.95–1.17

Note. N = 506. Sex was coded 0 = men, women = 1. IAT = Implicit Association Test. IATs were scored such that higher scores indicate stronger associations with the concepts in the IAT's name. Bolded values indicate statistically significant IAT scores. The IATs were lagged; models predict outcomes one time point later. Consumption = self-reported number of drinks consumed on a typical week. RAPI = scores on the Rutgers Alcohol Problem Index. AUDIT = scores on the Alcohol Use Disorder Identification Test.

*** $p < .001$.

** $p < .01$.

* $p < .05$.

Table 6

Lagged Models Evaluating IATs as Longitudinal Predictors of Alcohol Consumption

		Logistic portion of model			Count portion of model		
	Predictor	**Exp (*b*)**	***Z***	***95% CI***	**Exp (*b*)**	***Z***	***95% CI***
Lag 2 (*n* = 386)	Sex	0.61	−2.20*	0.40–0.95	0.96	−0.50	0.83–1.12
	Previous Consumption	0.40	−3.60***	0.25–0.66	1.07	13.18***	1.06–1.08
	Time	0.89	−2.37*	0.81–0.98	0.96	−2.20*	0.93–1.00
	Identity IAT	1.01	0.03	0.64–1.60	**1.25**	**2.80****	**1.07–1.47**
	Excitement IAT	0.92	−0.40	0.60–1.40	**1.17**	**2.13***	**1.01–1.36**
	Approach IAT	**0.51**	**−2.50***	**0.30–0.86**	1.03	0.38	0.88–1.21
Lag 3 (*n* = 379)	Sex	0.50	−2.42*	0.28–0.88	1.00	0.03	0.84–1.20
	Previous Consumption	0.18	−1.12	0.01–3.71	1.07	8.88***	1.05–1.08
	Time	0.92	−1.11	0.80–1.06	0.99	−0.28	0.94–1.04
	Identity IAT	1.42	1.29	0.83–2.40	**1.33**	**2.85****	**1.09–1.61**
	Excitement IAT	0.66	−1.47	0.38–1.15	1.15	1.52	0.96–1.37
	Approach IAT	**0.50**	**−1.97***	**0.25–1.00**	0.99	−0.05	0.81–1.22
Lag 4 (*n* = 363)	Sex	0.51	−2.28*	0.29–0.91	0.92	−0.74	0.75–1.14
	Previous Consumption	0.26	−1.92	0.07–1.03	1.06	8.44***	1.05–1.07
	Time	0.89	−1.37	0.76–1.05	0.97	−0.93	0.91–1.03
	Identity IAT	1.36	1.01	0.75–2.47	**1.28**	**2.20***	**1.03–1.59**
	Excitement IAT	0.91	−0.30	0.49–1.68	1.16	1.52	0.96–1.42
	Approach IAT	0.49	−1.95	0.24–1.00	0.98	−0.16	0.80–1.20
Lag 5 (*n* = 344)	Sex	0.57	−1.85	0.32–1.04	1.00	−0.01	0.81–1.24
	Previous Consumption	0.35	−3.49***	0.19–0.63	1.06	8.24***	1.04–1.07
	Time	0.82	−1.69	0.66–1.03	0.99	−0.20	0.91–1.08
	Identity IAT	1.91	1.95	1.00–3.66	**1.44**	**3.25****	**1.16–1.80**
	Excitement IAT	0.91	−0.29	0.49–1.71	1.04	0.33	0.82–1.31

		Logistic portion of model			Count portion of model		
	Predictor	**Exp (*b*)**	***Z***	***95% CI***	**Exp (*b*)**	***Z***	***95% CI***
	Approach IAT	**0.48**	**−2.03***	**0.23–0.97**	1.19	1.32	0.92–1.55
Lag 6 (*n* = 315)	Sex	0.60	−1.56	0.32–1.14	1.06	0.49	0.83–1.36
	Previous Consumption	0.45	−4.23***	0.31–0.65	1.04	5.99***	1.03–1.06
	Time	0.79	−1.15	0.53–1.18	1.04	0.45	0.88–1.23
	Identity IAT	1.70	1.49	0.85–3.42	**1.38**	**2.60****	**1.08–1.76**
	Excitement IAT	0.97	−0.10	0.50–1.87	1.21	1.59	0.96–1.52
	Approach IAT	0.65	−1.01	0.28–1.50	1.08	0.52	0.81–1.45
Lag 7 (*n* = 276)	Sex	0.79	−0.70***	0.40–1.54	0.86	−1.20	0.68–1.10
	Previous Consumption	0.51	−4.76***	0.38–0.67	1.04	5.48***	1.02–1.05
	Identity IAT	1.14	0.31	0.50–2.61	**1.50**	**2.86****	**1.14–1.99**
	Excitement IAT	0.68	−1.01	0.32–1.45	1.19	1.30	0.92–1.54
	Approach IAT	0.62	−0.96	0.24–1.63	0.99	−0.09	0.73–1.34

Note. $N = 506$. Sex was coded 0 = men, women = 1. IAT = Implicit Association Test. IATs were scored such that higher scores indicate stronger associations with the concepts in the IAT's name. Bolded values indicate statistically significant IAT scores Consumption = self-reported number of drinks consumed on a typical week. Lagged models were run such that each possible lag (from 2 to 7) was evaluated using the following strategy: T_{j+2} drinking = T_j IATs, where j = a given assessment time point. Exp (*b*) = the exponentiated coefficient.

*** $p < .001$.

** $p < .01$.

* $p < .05$.