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A prospective study of alcohol involvement and the dual-systems model of adolescent risk-taking during late adolescence and emerging adulthood.

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Abstract

Aims: To estimate interactions and unique effects of behavioral approach and behavioral control on alcohol involvement hypothesized by dual-systems models, during adolescence and emerging adulthood.

Design: In a longitudinal study, behavioral approach and behavioral control were examined in relation to alcohol involvement, cross-sectionally and prospectively.

Setting and Participants: 846 general population twins born in Colorado, USA were assessed twice ($M=17.3$ and 22.8 years-old; female=51.4%; White=91.8%).

Measurements: Behavioral approach was measured by self-report questionnaires of sensation seeking and subjective effects of alcohol. Behavioral control was measured by self-reported lack of planning and nine executive functioning (EF) tasks. Interviewers administered semi-structured clinical interviews to assess alcohol use and disorder (AUD).

Findings: None of 36 interaction effects was statistically significant ($\beta=-0.16-0.14, p>.06$), suggesting dual systems are additively related to alcohol involvement. In multiple regression models, behavioral approach and behavioral control explained independent variance in alcohol use quantity ($\beta=0.09-0.33, p<.04$) and frequency ($\beta=-0.11-0.29, p<.03$) at both waves. During adolescence, only subjective effects ($\beta=0.27-0.28, p<.001$) explained independent variance in AUD. Moreover, measures of the same construct explained independent variance in alcohol involvement: For behavioral control, lack of planning and EF were associated with alcohol frequency in adolescence ($\beta=-0.11-0.25, p<.02$) and AUD in emerging adulthood ($\beta=-0.09-0.16, p<.03$). For behavioral approach, subjective effects were associated with all measures at both waves ($\beta=0.20-0.33, p<.01$), and sensation seeking was associated with all measures in emerging adulthood ($\beta=0.09-0.11, p<.04$). In prospective models, adolescent alcohol involvement was associated with later lack of planning ($\beta=0.12-0.18, p<.03$), and lack of planning in adolescence was associated with later alcohol involvement ($\beta=0.12-0.14, p<.02$).

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Conclusions: Both the behavioral approach and behavioral control components of dual-systems models explain alcohol involvement during adolescence and adulthood, and different measures of the same system assess separate risk processes. The relations between alcohol involvement and the dual systems appear to be bidirectional.

Keywords

alcohol abuse; development; personality; top-down; bottom-up; executive functions; novelty seeking; sensation seeking; subjective effects; inhibition

Dual-systems models attribute behavior to two complementary systems: 1) an affective system characterized by sensation seeking [1]; and 2) a cognitive system characterized by behavioral control [2]. These models are largely based on developmental evidence that sensation seeking increases rapidly and behavioral control increases gradually during adolescence, resulting in a period of greater risk-taking [3]. Research has examined the interplay between sensation seeking and behavioral control in relation to alcohol use disorder (AUD), including studies of correlated changes among these systems and substance use [4–7]. However, longitudinal evidence is lacking on how these systems relate to substance involvement at different developmental stages. These risk factors may be particularly important for alcohol involvement in the transition to emerging adulthood, when use is elevated [8–10]. The current study used a longitudinal sample to examine the unique contributions of behavioral approach and control to alcohol involvement during adolescence and emerging adulthood.

The components of dual-systems models correspond to commonly used measures. Sensation seeking maps onto Gray's behavioral approach system (i.e., appetitive motivation) and represents drive for reward [11,12]. Behavioral control maps onto Gray's behavioral inhibition system (or *lack of planning*) for considering consequences and controlling impulses [13,14]. Thus, these systems are theoretically distinct. Further, factor analyses have identified sensation seeking and lack of planning as distinct (but correlated; $r=.34$) facets of impulsivity [15], which also correlate with alcohol use and alcohol-related problem [16]. Importantly, behavioral approach and control have been assessed in many ways. Behavioral approach can be assessed by reward drive, broadly (e.g., sensation seeking), and specific to certain stimuli (e.g., subjective effects). Behavioral control includes lack of planning and executive functioning (EF), which are conceptually opposite ends of the same spectrum [13], but are weakly correlated [17]. It is unclear whether these related systems represent distinct risk processes for alcohol involvement, or whether different measurements of the same "system" assess separate risk processes.

Sensation seeking increases rapidly in early adolescence (around age 15) and decreases thereafter, whereas lack of planning decreases gradually through emerging adulthood [5,6,18,19]. Consequently, the faculties that control the urge(s) to engage in risky behavior lag behind the urges themselves. Additionally, substance use peaks in emerging adulthood [8]. Given these developmental patterns, each system may relate to substance use differently across development. Findings from the current sample suggest that EF is related to substance

use in adolescence but not emerging adulthood [20]. Thus, the functional relationships that underlie dual-systems models may vary by age.

The present study investigates how behavioral approach and control relate to alcohol involvement during adolescence and emerging adulthood. This work extends prior studies by examining the unique contributions of self-report and behavioral measures on alcohol involvement in adolescence and emerging adulthood. Analyses addressed the following research questions (RQs):

- RQ1** Do interaction effects between behavioral approach and control explain alcohol involvement?
- RQ2** Do behavioral approach and control explain independent variance in alcohol involvement?
- RQ3** Do alternative measures of the same risk processes explain independent variance in alcohol involvement (i.e., sensation seeking vs. subjective effects for approach; lack of planning vs. EF for control)?
- RQ4** Do behavioral approach and control prospectively predict alcohol involvement from adolescence to emerging adulthood?

The most straightforward prediction from the dual-systems model is that these constructs interact to explain variance in alcohol involvement. However, if these constructs do not interact, but rather additively explain variance in alcohol involvement, this would still be consistent with the dual-systems model, but would suggest a simpler relationship than currently proposed. If these systems explain the same variance in alcohol involvement, this would be difficult to reconcile with the dual-systems model.

Methods

Design

This study examined main and interaction effects of behavioral approach and control on alcohol involvement using a general population sample. Effects were assessed cross-sectionally and prospectively in two waves (adolescence, emerging adulthood). At both waves, diverse measures of behavioral approach (sensation seeking, subjective effects) and control (lack of planning, EF) were assessed, with normative and problematic alcohol involvement as outcomes. Thus, the importance of each measure to alcohol involvement was assessed relative to the other measures.

Participants

846 individual twins in the Longitudinal Twin Study (LTS; 51.4% female) completed questionnaires, EF tasks, and substance use interviews in adolescence ($n=797$; $M_{\text{age}}=17.3$ years [$SD=0.6$]) and emerging adulthood ($n=762$; $M_{\text{age}}=22.8$ [$SD=1.3$]). Most participants completed both waves ($n=713$). The EF, self-report, and clinical interview assessments occurred on the same day in adolescence, and typically within a week in emerging adulthood. The LTS is a sample of twin pairs born in Colorado, within approximately a three-hour drive of Boulder [21 for a full description]. The sample is representative of

Colorado at the time of recruitment (91.8% White, 5.6% multiracial, 1.2% American Indian, 0.2% Native Hawaiian/Pacific Islander, 1.2% unknown/unreported race; 9.3% Hispanic). The study was approved by the Institutional Review Board at the University of Colorado Boulder.

Measures

Alcohol Involvement.—Trained interviewers administered the Composite International Diagnostic Interview (CIDI), a structured interview based on psychiatric symptoms from the Diagnostic and Statistical Manual and International Classification of Diseases. The CIDI has been validated in general population samples [22,23]. The Substance Abuse Module [CIDI-SAM; 24] and supplemental questions administered after the CIDI interview assessed alcohol use and AUD symptoms.

Assessments included alcohol frequency (*How many days have you used alcohol in the past six months?*) and quantity (*Number of drinks in (an) average week*). All alcohol variables were non-normal (skewness>2; see Table 1) and, thus, binned and analyzed with a threshold model, which yields unbiased estimates [25]. For frequency, participants were classified as abstaining (Wave1=54%, Wave2=9%), drinking 10 or fewer days (Wave1=34%, Wave2=28%), and drinking more than 10 days in the past six months (Wave1=13%, Wave2=63%). For quantity, participants who had ever drunk were classified as typically having zero drinks (Wave1=19%, Wave2=5%), four or fewer drinks (Wave1=45%, Wave2=47%), and five or more drinks in a week (Wave1=36%, Wave2=49%).

For AUD, an approximate lifetime, DSM-5 AUD diagnosis was used (excluding “craving,” which was not yet in the CIDI). Participants were classified as having mild (2–3 symptoms; Wave1=8%, Wave2=21%), moderate (3–4 symptoms; Wave1=3%, Wave2=9%), or severe AUD (5+ symptoms; Wave1=2%, Wave2=5%). AUD symptoms demonstrated adequate internal consistency at both waves ($\alpha=.82-.84$).

Personality.—Self-report items assessing behavioral approach and control are provided in supporting material. At Wave1, participants completed the 54-item Tridimensional Personality Questionnaire (TPQ) and a short form (18-item) of the Eysenck Personality Questionnaire (EPQ) [26–28]. Both questionnaires consist of binary items and include subscales relevant to the dual-systems model.

All TPQ and EPQ items were analyzed with the *omega* function within the *psych* package in R to identify items that measure the same constructs [29]. Specifically, a hierarchical factor structure with oblique rotation was assessed, wherein a higher-order factor describes covariation among all items (e.g., risk-taking) and lower-order factors describe covariation among subsets of items (e.g., sensation seeking, behavioral control). The item content of the lower-order factors was assessed to identify item subsets relevant to the current study.

At Wave1, a sensation seeking scale was comprised of five items from the TPQ exploratory excitability subscale (e.g., “*I often try new things just for thrills*”) and the nine-item EPQ extraversion scale (e.g., “[*I like plenty of excitement*”). A lack of planning scale was comprised of five items from the TPQ impulsiveness subscale (e.g., “[*I often follow my*

instincts, hunches, or intuition”). These scales were non-normal and binned. For sensation seeking, 50% of participants were classified as low (items endorsed $\leq 22\%$), 27% as moderate (endorsement $\leq 41\%$), and 23% as high (endorsement $> 41\%$). For lack of planning, 47% of participants were classified as low (endorsement $\leq 40\%$), 38% as moderate (endorsement $\leq 80\%$), and 15% as high (endorsement $= 100\%$). Items for these measures demonstrated adequate internal consistency ($\alpha = .66-.67$).

At Wave2, participants completed a 35-item form of the UPPS-P Impulsive Behavior Scale, which was developed from factor analyses of items from several personality questionnaires including the TPQ and EPQ [14,30]. The UPPS-P is a multifaceted Likert-rating impulsivity scale; we used a 7-item *sensation seeking* scale (e.g., “*I generally seek new and exciting experiences and sensations*”) and 8-item *lack of planning* scale (e.g., “*I usually think carefully before doing anything*”). Across waves, sensation seeking measures were correlated ($r = .23$ [95% CI = .14, .31]) and lack of planning measures were correlated ($r = .25$ [95% CI = .17, .33]).

Participants who met criteria to be asked about AUD symptoms (denied that they had *never drank alcohol OR never drank regularly and never gotten drunk and had no alcohol problems*) also completed the 13-item Lyons Subjective Effects scale [31,32]. Items assessed the acute effects of alcohol “*in the period shortly after you used*.” Analyses using the *omega* function in the *psych* package identified six items for positive subjective effects (e.g., *mellow/relaxed*) and six items for negative subjective effects (e.g., *nauseous*). Positive subjective effects were examined as an alcohol-specific measure of behavioral approach. Scales were non-normal and binned. For positive subjective effects, participants who drank were classified as low (endorsement $\leq 50\%$; Wave1 = 60%, Wave2 = 56%) or high. For negative subjective effects, participants who drank were classified as low (endorsement $< 33\%$; Wave1 = 44%, Wave2 = 46%) or high. At both waves, both scales demonstrated adequate internal consistency ($\alpha = .65-.74$).

Executive Functioning.—Nine computerized EF tasks assessed response inhibition (antisaccade, stop-signal, and Stroop), working memory updating (keep track, letter memory, and spatial *n*-back), and mental set shifting (number–letter, color–shape, and category-switch) (for details, see [33,34]). Extensive work has demonstrated the multifaceted nature of EF [35,36]. The current study used a measure of “Common EF”, based on evidence from this sample that the variance shared across measures of EF is more consistently related to substance involvement than specific facets of EF [20]. Specifically, we averaged z-scores of all 9 EF tasks at each wave (see Friedman et al. [33]; see supporting information for full description), after reverse-scoring relevant tasks so that higher scores indicate better performance.

Analytic Procedures

All analyses were conducted with Mplus, version 7.4 [37]. Given the ordinal nature of variables, analyses used a robust weighted least squares with mean and variance adjustment (WLSMV) estimator. Further, all analyses included a family identifier as a cluster variable to account for non-independent observations from the same family. For all analyses following

RQ1, all predictor and outcome variables were regressed on age and sex, so that all ordinal data were modeled with thresholds and individuals with partially missing data were included (WLSMV uses pairwise deletion) [38]. The statistical significance of all parameters was based on the path coefficient and standard error estimates provided by Mplus.

First, regression models with interaction effects consistent with dual-systems models were conducted (RQ1). In each model, one alcohol use measure was regressed on one pair of approach and control measures and their interaction, resulting in 36 models. Thresholds were modeled for ordinal dependent variables, which were assumed to be normal conditional on the predictors. Thus, these models only included individuals with complete data for the predictors. Interaction effects were negligible and omitted from subsequent analyses. Second, regression models examined whether behavioral approach and control explain independent variance in alcohol involvement (RQ2), and whether measures of the same risk processes (i.e., approach or control) explain independent variance in alcohol involvement (RQ3). In each model, one alcohol use dependent variable was regressed on all behavioral approach and control predictors for the same wave, resulting in six models. All predictor and outcome variables were regressed on age and sex, and ordinal measures, including independent variables, were modeled with thresholds, so individuals with partially missing data were included. Finally, longitudinal cross-lag panel models (one for each alcohol measure) examined whether behavioral approach and control were prospectively associated with alcohol involvement from adolescence to emerging adulthood (RQ4).

Results

Preliminary analyses

Table 1 provides descriptive statistics and correlations. For variables that were binned to handle non-normality, thresholds and polychoric/polyserial correlations were estimated. At Wave1, alcohol involvement (quantity, frequency, and AUD) was generally associated with higher positive subjective effects ($r=.18$ to $.37$), negative subjective effects ($r=.07$ to $.38$), lack of planning ($r=.13$ to $.28$), and lower EF ($r=-.13$ to $-.14$). Sensation seeking, however, was unrelated to alcohol involvement at Wave1, except for alcohol frequency ($r=.03$ to $.13$).

At Wave2, alcohol involvement was generally associated with higher sensation seeking ($r=.18$ to $.21$), positive subjective effects ($r=.31$ to $.45$), negative subjective effects ($r=.18$ to $.38$), and lack of planning ($r=.10$ to $.26$). EF, however, was unrelated to alcohol involvement at Wave2, except for AUD ($r=-.01$ to $-.10$).

Sensation seeking and lack of planning were moderately correlated, consistent with prior studies of dual-systems models ($r=.18$ to $.30$). Further, EF and lack of planning were not significantly correlated, as previously demonstrated ($r=-.08$;[16]). Positive and negative subjective effects were uncorrelated at Wave1 but moderately correlated at Wave2 ($r=.36$).

RQ1) Do interaction effects between behavioral approach and control explain alcohol involvement?

Interaction effects were tested for every measure of behavioral approach (sensation seeking, positive/negative subjective effects) and control (lack of planning, EF) on every alcohol

outcome (quantity, frequency, AUD) at Waves 1 ($n=269-789$) and 2 ($n=690-745$). All 36 interaction effects were negligible and all $p>.05$, suggesting behavioral control does not moderate the effect of behavioral approach on alcohol involvement (see Table S6, supporting material).¹ Thus, interaction effects were removed from subsequent models.

RQ2) Do behavioral approach and control explain independent variance in alcohol involvement?

Multiple regression models assessed the variance explained in alcohol involvement by each behavioral approach and control measure, controlling for all other measures (see Table 2). At Wave1, behavioral control measures of lack of planning and EF explained independent variance in alcohol quantity, and lack of planning also explained alcohol frequency. Further, subjective effects explained independent variance in all alcohol measures. Notably, AUD at Wave1 was associated *only* with greater positive and negative subjective effects.

At Wave2, behavioral control measures of lack of planning and EF explained independent variance in AUD, and lack of planning explained typical quantity. Further, all behavioral approach measures explained independent variance in all alcohol involvement. Notably, AUD was associated with all behavioral approach and control measures, but alcohol frequency was associated only with sensation seeking and positive subjective effects. Importantly, squaring the standardized regression coefficients shows that many statistically significant effects were of small magnitude (~1% of variance); however, some effects were large (6–11% of variance for subjective effects). Overall, models explained 12–31% of variation in alcohol involvement.

RQ3) Do alternative measures of the same risk processes explain independent variance in alcohol involvement?

Both behavioral control measures at Wave1 (EF, lack of planning) explained independent variance in past-year frequency, and neither explained variance in AUD. In contrast, at Wave2, neither measure was associated with past-year frequency, but both were associated with AUD. Notably, typical quantity at both waves was associated with lack of planning but not EF.

For behavioral approach measures, positive subjective effects were associated with all measures of alcohol involvement at both waves. Notably, sensation seeking was unrelated to all measures of alcohol involvement at Wave1 but was associated with all measures at Wave2. Finally, negative subjective effects were associated with typical quantity at Wave1 and AUD at both waves.

RQ4) Do behavioral approach and control prospectively predict alcohol involvement from adolescence to emerging adulthood?

A final set of models examined both waves together ($n=846$). Separate models were conducted for each dependent variable (frequency, quantity, AUD symptoms). Thus, after accounting for autoregressive effects from Wave1, these models examined the prospective

¹Conclusions did not change when using log-transformed continuous outcomes instead of binned outcomes.

effects from Wave1 to Wave2 (via cross-lag paths; see Figure 1) and cross-sectional effects at Wave2 (via residual correlations). The latter describe whether within-wave relationships capture new covariance that was not accounted for by the Wave1 variables.

After accounting for autoregressive paths, positive and negative subjective effects were positively associated with alcohol involvement within Wave2 ($r=.23$ to $.43$). Sensation seeking was positively associated with alcohol use frequency ($r=.14$) and quantity ($r=.12$), and lack of planning was positively associated with AUD ($r=.14$) and typical quantity ($r=.15$). EF was unrelated to alcohol involvement at Wave2, but the autoregressive path explained approximately 50% of the variance in EF.

For prospective effects, lack of planning was the only risk factor at Wave1 associated with alcohol involvement at Wave2 (significant β s=0.12 to 0.14). Notably, *all* measures of alcohol involvement at Wave1 were prospectively associated with higher sensation seeking and lack of planning at Wave2 (β s=0.11 to 0.18). Further, AUD at Wave1 was associated with higher negative subjective effects at Wave2 ($\beta=0.19$), and frequency at Wave1 was associated with higher positive subjective effects at Wave2 ($\beta=0.13$).

Discussion

This study examined the relevance of diverse measures of behavioral approach and control to alcohol involvement. Moderation effects, central to some conceptualizations of dual-systems models, were negligible (RQ1; e.g., see [39]). Both behavioral approach and control, however, explained independent variance in alcohol use (during adolescence and adulthood) and AUD (during emerging adulthood) (RQ2). Thus, both approach and control tendencies are related to alcohol involvement (RQ2), but being both high in approach and low in self-control does not pose additional risk that is missed by simply modeling both main effects on their own (RQ1). Nevertheless, our finding that both approach and control independently predict alcohol behaviors is consistent with the idea of dual-systems contributing to alcohol use behaviors, such that high control can offset the effects of high approach, rather than making approach levels irrelevant to alcohol use behavior.

With respect to alternative measures of each system, for behavioral control, lack of planning explained unique variance in typical quantity, but EF did not (RQ3). For behavioral approach, subjective effects explained independent variance in all measures of alcohol involvement during both waves, but sensation seeking was unrelated to alcohol involvement in adolescence (RQ3). This is consistent with evidence suggesting that reward response specific to alcohol may be a persistent risk factor for AUD, but general reward processes may be important only in adulthood [40,41]. Finally, prospective models found bidirectional effects between alcohol involvement with lack of planning (quantity, AUD) and sensation seeking (quantity) (RQ4).

Cross-sectional analyses suggested that risk factors for alcohol use vary across adolescence and emerging adulthood. EF was associated with alcohol use in adolescence and problems (AUD) in emerging adulthood, when drinking typically peaks [8]. In contrast, prior findings from this sample found no association between EF and illicit substance use disorders in

emerging adulthood [20]. Importantly, all behavioral control and approach measures were related to AUD in emerging adulthood, suggesting that multiple facets of approach and control may drive alcohol-related consequences during this period.

Findings from prospective analyses spanning adolescence and emerging adulthood are a particularly unique contribution to the literature with several implications. Importantly, these models included cross-lagged effects and, thus, prospective effects explained variance beyond what was explained by prior measures of each respective variable. For example, adolescent alcohol use was associated with later sensation seeking and lack of planning, even after accounting for adolescent sensation seeking and lack of planning. These stringent tests suggest that alcohol involvement may increase later impulsivity. Further, models suggested that adolescent planfulness may underlie the development of normative and problematic alcohol use. Thus, these findings suggest bidirectional associations between behavioral approach and control with alcohol involvement, across critical periods of elevated alcohol use. Similarly, within-wave correlations in emerging adulthood, for alcohol involvement with impulsivity and subjective effects, remained significant after this stringent test.

Finally, these findings are consistent with studies that have used diverse measures of risk-taking behavior to examine dual-systems models. Harden and colleagues factor analyzed three self-report and five performance-based measures of the dual systems in an exploratory structural equation model [42], identifying weak correlations among premeditation, fearlessness, reward seeking, and cognitive dyscontrol, suggesting that they capture independent variance. Thus, incorporating diverse measures of behavioral approach and control may increase prediction of substance use.

Limitations and Future Directions

The measurement of bottom-up urges and top-down control should be considered when evaluating these findings. Different measures of sensation seeking and lack of planning were used across waves. Observed differences by age could, therefore, be due to measurement rather than development. Laboratory measures of behavioral approach may provide further insight into relations between reward processing and alcohol use across time. Further, self-reported subjective effects may assess various types of variance, including methodological variance (e.g., interpretation) and constructs related to subjective effects of use (e.g., expectancies [45]). Neuroimaging approaches may elucidate how reward processes relate to the progression of alcohol involvement.

Additionally, contextual factors during emerging adulthood may work in conjunction with, or independent of, individual differences in behavioral control and behavioral activation. For example, alcohol involvement and behavioral control both increase during emerging adulthood, but evidence suggests that smaller increases in behavioral control occur among those with greater increases in alcohol involvement [7,46]. Further, social changes and family-role transitions are related to drinking, and these contextual factors are also predicted by personality maturation (e.g., inhibition; [10]).

Summary

The current findings suggest including both components of dual-systems models during the critical developmental periods of adolescence and emerging adulthood. Measures of both behavioral activation and control explained independent variance in alcohol involvement. Additionally, prospective models suggested bidirectional effects between behavioral control and alcohol involvement over time. Thus, disinhibition may be both a cause and consequence of alcohol use.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.

Standardized path coefficients from longitudinal models predicting alcohol use frequency (panel A), quantity (panel B), and disorder (panel C) with measures of behavioral approach (sensation seeking, subjective effects) and behavioral control (executive functioning, lack of planning) from Wave1 (age 17) to Wave2 (Age 23). Models included cross-lagged paths and residual correlations within-waves for all variables, but parameter estimates are depicted only for statistically significant paths ($p < .05$). Non-significant regression coefficients across waves are depicted by grey, dashed lines. Non-significant correlation paths are not displayed. The residual variance is displayed for all Wave2 variables. Freq.=alcohol frequency; Quan.=typical alcohol quantity; AUD=alcohol use disorder; SS=UPPS-P Sensation Seeking; LP=UPPS-P Lack of Planning; EF=executive functioning. See Table S7 in the supporting material for all estimates and standard errors.

Table 1.

Correlation coefficients between alcohol involvement and dual-systems measures at Waves 1 and 2.

	Wave1 (M age 17)							Wave2 (M age 23)								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Wave1 (M age 17)																
1) Alcohol Quantity ^a																
2) Alcohol Frequency ^a	.34 [*]															
3) AUD ^a	.51 [*]	.66 [*]														
4) TPQ/EPQ Sensation Seeking ^a	.05	.13 [*]	.03													
5) Lyons Positive Effects ^a	.37 [*]	.18 [*]	.30 [*]	.18												
6) Lyons Negative Effects ^a	.32 [*]	.07	.36 [*]	-.12	-.17											
7) TPQ Lack of Planning ^a	.15 [*]	.28 [*]	.13	.30 [*]	-.02	-.07										
8) Executive Functioning	-.13 [*]	-.13 [*]	-.14 [*]	.12 [*]	-.03	-.20 [*]	-.08									
Wave2 (M age 23)																
9) Alcohol Quantity ^a	.26 [*]	.34 [*]	.33 [*]	.18 [*]	-.14	-.12	.21 [*]	-.06								
10) Alcohol Frequency ^a	-.11	.33 [*]	.13 [*]	-.03	-.10	-.18	-.09	-.05	.52 [*]							
11) AUD ^a	.25 [*]	.41 [*]	.60 [*]	.13 [*]	-.15	.26 [*]	.22 [*]	-.07	.41 [*]	.22 [*]						
12) UPPS-P Sensation Seeking	-.10	.12 [*]	.17 [*]	.23 [*]	-.16	-.08	.14 [*]	-.02	.18 [*]	.17 [*]	.20 [*]					
13) Lyons Positive Effects ^a	.17 [*]	.20 [*]	.28 [*]	-.08	.32 [*]	-.08	-.03	-.03	.39 [*]	.31 [*]	.45 [*]	.20 [*]				
14) Lyons Negative Effects ^a	-.02	.12 [*]	.29 [*]	-.03	-.06	.37 [*]	-.08	-.03	.23 [*]	.18 [*]	.38 [*]	-.07	.36 [*]			
15) UPPS-P Lack of Planning	.12 [*]	.19 [*]	.21 [*]	.14 [*]	.17 [*]	-.10	.25 [*]	-.02	.22 [*]	.10 [*]	.26 [*]	.18 [*]	.19 [*]	-.08		
16) Executive Functioning	-.05	-.07	-.10	.16 [*]	-.09	-.22 [*]	-.02	.74 [*]	-.01	-.07	-.10 [*]	-.02	-.02	-.03	-.04	
<i>n</i>	416	791	793	794	274	274	795	786	715	759	762	746	702	746	749	
Mean	5.68	5.71	0.59	0.27	0.49	0.34	0.53	0.01	8.09	29.72	1.52	2.87	0.53	0.34	1.88	0.00
Standard Deviation	8.58	14.7	1.45	0.18	0.28	0.30	0.32	0.56	11.79	35.71	2.01	0.66	0.28	0.30	0.48	0.56
Skewness	3.84	4.87	3.34	-0.77	-0.03	0.52	-0.12	0.66	4.22	2.23	1.69	-0.42	-0.08	0.56	0.37	0.47

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	Wave1 (M age 17)								Wave2 (M age 23)							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Kurtosis	21.01	29.96	12.48	0.29	-0.86	-0.80	-1.16	0.95	24.40	5.55	2.74	-0.56	-0.91	-0.82	0.12	0.13
Cronbach's Alpha	NA	NA	0.84	0.66	0.65	0.71	0.67	0.72	NA	NA	0.82	0.81	0.68	0.74	0.82	0.72

* Note: $p < .05$.

^aBinned-variable. Correlations are polychoric (between binned measures), polyserial (binned and continuous measures), and Pearson coefficients (continuous measures). Descriptive statistics are for raw, unbinned data. AUD=alcohol use disorder symptoms; TPQ=Tridimensional Personality Questionnaire; EPQ=Eysenck Personality Questionnaire; UPPS-P=UPPS-P Impulsive Behavior Scale; NA=not available.

Table 2.

Standardized regression coefficients (standard errors) for multiple regression models predicting alcohol involvement

	Wave1 (<i>M</i> age=17 years) <i>n</i> =797			Wave2 (<i>M</i> age=23 years) <i>n</i> =762		
	Frequency (Past-Year)	Quantity (Typical)	AUD (Diagnosis)	Frequency (Past-Year)	Quantity (Typical)	AUD (Diagnosis)
Covariates						
Sex (female)	−0.15 ** (0.05)	−0.11 (0.06)	−0.09 (0.06)	0.03 (0.05)	−0.15 ** (0.05)	−0.01 (0.05)
Age	0.28 *** (0.05)	0.02 (0.06)	0.21 ** (0.05)	−0.03 (0.05)	0.00 (0.05)	0.08 (0.04)
Behavioral Control						
Executive Functioning	−0.11 * (0.05)	−0.07 (0.07)	−0.08 (0.06)	0.07 (0.05)	0.00 (0.04)	−0.09 * (0.04)
Lack of Planning	0.25 *** (0.05)	0.17 * (0.08)	0.14 (0.08)	0.03 (0.04)	0.14 ** (0.04)	0.16 *** (0.04)
Behavioral Approach						
Sensation Seeking	0.04 (0.05)	−0.02 (0.08)	−0.03 (0.08)	0.11 * (0.05)	0.09 * (0.05)	0.10 * (0.04)
Lyons Positive Effects	0.20 ** (0.06)	0.33 ** (0.10)	0.27 ** (0.08)	0.26 *** (0.07)	0.30 *** (0.06)	0.31 *** (0.06)
Lyons Negative Effects	0.04 (0.06)	0.25 ** (0.09)	0.28 *** (0.07)	0.08 (0.07)	0.10 (0.06)	0.25 *** (0.05)

Note.

 $p < .001$

**
 $p < .01$

*
 $p < .05$. For the sex variable, higher numbers indicate female. AUD=alcohol use disorder.