Published in final edited form as:
Psychol Addict Behav. 2008 June ; 22(2): 198–209. doi:10.1037/0893-164X.22.2.198.

Comparison of Longitudinal Phenotypes Based on Alternate Heavy Drinking Cut Scores:

A Systematic Comparison of Trajectory Approaches III

Kristina M. Jackson and
Center for Alcohol and Addiction Studies, Brown University

Kenneth J. Sher
Midwest Alcoholism Research Center and Department of Psychology, University of Missouri—Columbia

Abstract

The goal of the present study was to empirically determine the effect of employing different cut scores for frequency of heavy episodic drinking (HED; an often-used indicator of problematic alcohol involvement) within a longitudinal framework. Using data from a large prospective (9-wave) college student sample, the authors used latent class growth analyses to characterize developmental trajectories of HED based on alternate cut scores that varied in frequency of HED (defined by 5+ drinks per occasion), as well as to measure very heavy episodic drinking (12+ drinks per occasion). As cut score severity increased and base rates for HED correspondingly decreased, individuals were increasingly categorized into less severe classes. Concordance between trajectories ranged from small to moderate, with concordance using highly discrepant definitions of frequent HED being particularly low. HED trajectories based upon different cut scores were validated against a range of etiological and consequential correlates. No single cut score was superior to others in explaining variance in external validity indicators, suggesting that the choice of cut score should be based upon theoretical and clinical considerations. This study further extends the authors' prior work examining the effects of methodological factors that are critical to characterizing the developmental course of alcohol involvement.

Keywords

heavy drinking; binge drinking; trajectory; cut score; college

Given the rise of trajectory-based approaches in characterizing the developmental course of alcohol involvement over the lifespan, it is critical for researchers to examine the practical implications of measurement and design issues on the identification and properties of alcohol-related trajectories. In two previous articles (Jackson & Sher, 2005, 2006), we explored the influence of methodological features on trajectory identification, such as the type of measure of alcohol involvement used and the number and timing of assessment occasions. Left unaddressed in our prior work and by the field at large is the critical question of how different severities or thresholds of measurement might affect these trajectories. This issue is central

Correspondence concerning this article should be addressed to Kristina M. Jackson, Center for Alcohol and Addiction Studies, Brown University, Box G-S121-4, Providence, RI 02912. E-mail: kristina_jackson@brown.edu.

Preparation of this article was supported by National Institute on Alcohol Abuse and Alcoholism Grants K01 AA13938, R37 AA13987, R01 AA07231, and P50 AA11998.

when categorical indicators of an alcohol-related status (e.g., whether or not an alcohol use disorder, a symptom, or a certain level of drinking is endorsed) are being considered. In the present study, we extend our prior investigations on methodological variance in trajectory identification to consider the effect that differing cut scores in the frequency of heavy episodic drinking (HED) have on the prevalence of trajectory class membership and the correlates of trajectories.

We focus on HED, which gauges heavy consumption in a short time frame (Wechsler & Nelson, 2001), because it has been employed as an efficient indicator of risky or problematic alcohol involvement, particularly for college students who frequently engage in consumption at potentially harmful levels. HED has generally been defined as five or more drinks (sometimes four or more for women; Wechsler & Austin, 1998) on a single occasion. Both the National Institute on Alcohol Abuse and Alcoholism (NIAAA) Advisory Council Task Force (NIAAA, 2004) and the World Health Organization (2000) have endorsed HED definitions corresponding to roughly five or more drinks per occasion (although the NIAAA criteria emphasize the imprecision of any definition that fails to account for weight, duration of the drinking episode, and individual differences in pharmacokinetics, a position we wholeheartedly embrace). HED is associated with numerous adverse outcomes such as injury, unplanned sexual behavior, driving after drinking, and alcohol dependence (e.g., Knight et al., 2002; Wechsler & Austin, 1998; Wechsler, Davenport, Dowdall, Moeykens, & Castillo, 1994; Wechsler, Dowdall, Maenner, Gledhill-Hoyt, & Lee, 1998).

Practical clinical decisions related to treatment eligibility, hospitalization, and medication generally require that the researcher make a categorical distinction between high and low functioning or *caseness* (Ellickson, McGuigan, Adams, Bell, & Hays, 1996; Krueger, Watson, & Barlow, 2005; Widiger & Clark, 2000). For example, alcohol treatment programs may base eligibility criteria on HED (e.g., two or more HED occasions in the past 30 days, as in Borsari & Carey, 2005). Unfortunately, such categorical distinctions of what is problematic behavior are determined based on arbitrary decisions about where cut points should be drawn rather than on empirical data (Hilton, 1987; Widiger & Samuel, 2005). Some researchers have made a distinction on the basis of *any* heavy drinking; others have made a determination on the basis of their own supposition of what is abnormally frequent (e.g., HED on a weekly basis). Wechsler and colleagues (e.g., Wechsler & Nelson, 2001; Wechsler et al., 2002) categorized HED as “frequent” if it occurred three or more times in a 2-week period, and some other researchers have adapted this definition (LaBrie, Pedersen, & Tawalbeh, 2007; A. M. White, Kraus, & Swartzwelder, 2006). In a study that characterized developmental course of heavy drinking, Schulenberg, O’Malley, Bachman, Wadsworth, and Johnston (1996) defined frequent heavy drinking as two or more HED episodes in 2 weeks; this is consistent with the notion of weekly HED as an indicator of problematic drinking (as in Greenfield, Midanik, & Rogers, 2000; Hilton, 1991). Thus, frequent HED is defined in alternative ways by various investigators with no clear consensus as to where the threshold for frequency should be drawn. It is also possible to conceive of a different type of cut score based on number of drinks per occasion as opposed to frequency of HED. For example, an episode of HED may be defined as consumption of 12 or more drinks per occasion (consistent with other research exploring alternate definitions of HED; Graham, Demers, & Rehm, 2004; Graham, Massak, Demers, & Rehm, 2007). Research has not yet systematically addressed the utility of alternate HED thresholds based on volume (although see Jackson, 2008).

Additionally, the meaning of HED (and thus the implications of a cut score for defining severe HED) is likely to differ as a function of developmental stage. Among young adults, college freshman have the highest rates of heavy drinking (Engs, Diebold, & Hanson, 1996), and in general, HED declines over the transition to young adulthood, although a sizeable minority of young adults continue to drink at risky levels. Studies of HED trajectories (e.g., Chassin, Pitts,

& Prost, 2002; Oesterle et al., 2004; Schulenberg, O'Malley, et al., 1996; Schulenberg, Wadsworth, O'Malley, Bachman, & Johnston, 1996; Tucker, Orlando, & Ellickson, 2003; Windle, Mun, & Windle, 2005) clearly have shown that the characteristic courses of alcohol involvement generally appear nothing like the average trajectory of use. For example, although a mean trajectory may show relative stability over time, there may be subgroups of individuals whose drinking steadily increases or decreases.

The current study seeks to determine the implications of employing different cut scores in portraying the developmental courses of heavy alcohol use and to explore the possibility that there is an optimal cut score that will permit researchers to capture the maximum amount of heterogeneity in trajectories of heavy alcohol use. Although traditional cut score analyses are based upon optimizing the trade-off between sensitivity and specificity with respect to a given criterion, for our purposes, we are interested in cut scores that yield trajectories that show the greatest variability across a range of external criteria. On a priori grounds we expect a definition of frequent HED that uses a liberal cut score (e.g., any HED based on the 5+ drink standard definition) to fail to resolve more than a minimal number of classes (those who do vs. do not engage in HED). In contrast, the use of a more severe cut score will permit the identification of a group of individuals who "mature out" of heavy alcohol involvement as well as the identification of those for whom heavy drinking increases over time. Yet, a cut score that is too severe will be unable to resolve variability in low frequency drinking and will fail to characterize problems that might be of clinical and public health concern (but would not be categorized as such). Understanding how the employment of different cut scores affects the types of trajectories obtained represents a necessary step in the development of trajectories that are optimally informative.

Method

Participants and Procedure

Participants were drawn from a sample of 3,720 entering first-time college students aged 19 years or younger who enrolled at a large midwestern university on the first day of classes (54% female, 46% male; 90% non-Hispanic White, 10% other races/ethnicities; mean age of 18.0 years; for a study overview, see Sher & Rutledge, 2007). During a campus-based freshman orientation session, participants completed a 30-min paper-and-pencil questionnaire assessing precollege alcohol and substance use and other relevant domains in a large group setting (a subset of participants completed mailed questionnaires after the orientation had ended). During the fall semester, the 3,720 precollege participants were recontacted and invited to participate in a series of 40- to 60-min web-based assessments that took place during each semester; participants were included whether or not they remained enrolled at the university. Thus, there were eight waves over a 4-year period as well as the precollege assessment. The web-based survey focused on alcohol and substance use during each semester as well as on substance-related cognitions, peer norms, broad personality domains, and other established etiological predictors of young adult substance use.

Retention rates for any one follow-up survey averaged between 75%-80%. Because 289 (7.8%) respondents participated only at Wave 0 (precollege assessment) and 373 (10.0%) participated only in one additional wave beyond Wave 0, we restricted the sample to those participants who completed at least two waves of the college assessment as well as the precollege assessment (i.e., at least three measurement occasions total). These participants (N = 3,058; 57.9% female, 42.1% male; 90.4% non-Hispanic White, 4.6% Black, 3.1% Asian, 1.9% other races/ethnicities; mean age of 17.9 years) were similar to the precollege sample with respect to ethnicity and age but were more likely to be female (58% vs. 54%). Retained participants were also more likely to have good high school academic performance (ACT composite score percentile), less likely to report substance use during their senior year of high school, and less likely to associate with peers who drank (Sher & Rutledge, 2007).

Measures

Heavy alcohol consumption—Frequency of HED was assessed with an item which inquired about the number of times in the past 30 days the participant had consumed five or more drinks in a row at a single sitting. There were eight response options: 0 = *did not in the past 30 days*; 1 = *once in the past 30 days*, 2 = *two to three times in the past 30 days*, 3 = *once or twice a week*, 4 = *three to four times a week*, 5 = *five to six times a week*, 6 = *nearly every day*, 7 = *every day*, 8 = *twice a day or more*. Due to low base rates in the top four categories (2.8% at Wave 0, < 2% at Waves 1-8), the top five categories were collapsed into a single category. Frequency of heavy drinking at each wave is portrayed in Figure 1. For this study, we alternatively categorized the heavy drinking measure in four ways, creating four dichotomous variables based on different cut scores (CS); CS 1: 5+ drinks at least once in the past 30 days; CS 2: 5+ drinks at least two to three times in the past 30 days; CS 3: 5+ drinks at least once or twice a week; and CS 4: 5+ drinks at least three times a week. In addition, we created a fifth cut score (CS 5) based on whether or not the participant had consumed 12+ drinks in a row at a single sitting in the past 30 days (response options as above) to compare thresholds based on volume vs. thresholds based on frequency.

Validity indicators—We sought to validate the HED cut scores using an array of etiological and consequential correlates. We selected as candidate variables those shown to be predictive of and/or out-comes of HED (see H. R. White & Jackson, 2004-2005). When possible, we considered the variable both at study outset (Wave 0; Wave 1 if the variable was not available at Wave 0) and at study end (Wave 8; Wave 7 if the variable was not available at Wave 8).

Gender data were obtained from the university registrar (when registrar data were not available, self-reported gender was used). Childhood conduct disorder was assessed at Wave 1 using a count of 10 items such as “skip school,” “run away,” or “use a weapon” that were endorsed as having occurred before age 15, consistent with Diagnostic and Statistical Manual of Mental Disorders (4th ed.; American Psychiatric Association, 1994) criteria. Extent of Greek involvement at Wave 1 was assessed by asking the respondent “Are you a member of a fraternity or sorority?” Response options included the following: 0 = *no, not member, never attend*; 1 = *no, not member, occasionally attend*; 2 = *no, not member, regularly attend*; 3 = *yes*.

Novelty seeking at Waves 1 and 7 was assessed using the 13-item short version (Sher, Wood, Crews, & Vandiver, 1995) of the Novelty Seeking scale of the Short Tridimensional Personality Questionnaire (Cloninger, 1987b; $\alpha = .72$). For 239 participants who were not assessed at Wave 1, novelty seeking was assessed at Wave 2 using a supplemental questionnaire. Coping and enhancement reasons for drinking at Waves 0 and 7 were assessed with a five-item coping subscale ($\alpha = .96$) and a five-item enhancement subscale ($\alpha = .97$) from Cooper’s (1994) 20-item scale. Response options were 0 = *never been a drinker*; 1 = *strongly disagree*; 2 = *slightly disagree*; 3 = *slightly agree*; 4 = *strongly agree*. Scores were computed only for those participants who indicated they were “drinkers.”

Past-year (Wave 0) and past 3-month (Wave 8) alcohol consequences (e.g., “Have you had a blackout from drinking?”) were assessed with a 37-item expanded item set based upon the Young Adult Alcohol Problems Screening Test (Hurlbut & Sher, 1992).

Analytic Approach

To identify trajectories of heavy drinking at each cut score, we used a mixture modeling procedure (Jones, Nagin, & Roeder, 2001; B. Muthén, 2001; B. Muthén & Muthén, 2000), latent class growth analysis. This technique is a form of latent growth modeling that identifies homogeneous classes of individuals on the basis of their pattern of endorsement over time. This analysis has some important advantages over other techniques used to derive developmental courses of substance use (e.g., cluster analysis, latent class analysis), as it treats group membership as a latent (error-free) variable, and it is appropriate for prospective data. Note that this "person-based" model can be conceptualized as an analog to factor analysis, where groups of individuals (rather than sets of variables) are extracted. In the present study, the latent class growth analyses were based on a basic latent growth model which included intercept as well as linear and quadratic slopes (set according to the interval between assessments; see Figure 2). In latent class growth analysis, no variation across individuals within a class is assumed (Nagin, 1999; Roeder, Lynch, & Nagin, 1999). Although this might seem like an unnecessary restriction, permitting variation around the group mean results in a far more complex model (Nagin & Tremblay, 2005); in practice, relaxing this assumption frequently results in greater likelihood of encountering convergence problems.

Trajectory models were estimated using Mplus (Version 4.10; L. K. Muthén & Muthén, 1998-2006). Models were estimated with automatically generated random start values using full information maximum likelihood, which assumes data are missing at random. We relied on three criteria to determine number of classes. As recommended by B. Muthén (2004), model fit was primarily evaluated using a likelihood ratio test for relative improvement in fit, the Vuong-Lo-Mendell-Rubin likelihood ratio test (VLMR LR; Lo, Mendell, & Rubin, 2001).[1] Given the large sample size, we used a conservative criterion of $\alpha = .01$ to determine whether a model yielded improved fit according to the VLMR LR test. We also considered an information criteria fit index (Bayesian information criterion; Schwarz, 1978) as well as class interpretability (the extent to which an additional class provided unique information) when determining number of classes.

Results

Identification of Trajectories

We tested a one- through seven-class model for each cut score (see Table 1). On the basis of the VLMR LR test, the five-class model was generally the best-fitting model and yielded the most interpretable classes. Although four classes were sufficient for the most severe 5+ cut score (at least three times per week) according to the VLMR LR test, the Bayesian information criterion supported a five-class model, and we preferred the five-class model for comparability across solutions using alternative cut scores. Although prevalences were small for the most severe classes in this model, our sample size was large, and we felt that these classes were clinically meaningful. In addition, although the six-class solution was best for the second cut score analysis (two to three times in the past 30 days), the additional class was not informative, corresponding to a moderate likelihood of engaging in HED at all time points.

Figure 3 presents the developmental courses for the five HED cut scores. Group membership for each was characterized by the following trajectories: (a) an increasing class that showed a some-what early onset and a chronic high progression (ranging from 2% to 21%), (b) a later-onset increase class (from 9% to 15%), (c) a chronic high class (from 3% to 40%), (d) a class that decreased over time (from 8% to 17%), and (e) a non-HED class (from 16% to 68%).

[1]Although B. Muthén (2004) also recommended use of the parametric bootstrapped likelihood ratio test (McLachlan & Peel, 2000), we found that the significance of the test exceeded $p > .0001$ in only 1 of the 35 (seven classes × five cut score models) analyses.

Comparison of Trajectories

To determine concordance of class membership across cut scores, we assigned respondents to their most likely class membership for each cut score. Contingency tables were created for each of the 10 pairwise comparisons (e.g., CS 1 vs. CS 2, CS 1 vs. CS 3, CS 2 vs. CS 3, etc.). For each of the comparisons, agreement was low to moderate in magnitude: Cramer's *V*, a normed measure of association that represents percentage of maximum possible variation between two variables, ranged from .25 to .55 (see upper diagonal of Table 2) and Cohen's (1960) kappa ranged from .07 to .47 across the pairwise comparisons (see lower diagonal of Table 2). The greatest concordance was observed between HED of 12+ drinks at least once in the past 30 days (CS 5) and HED of 5+ drinks at least once or twice a week (CS 3; $\kappa = .47$), although the latter was also highly associated with HED of 5+ drinks at least two to three times in the past 30 days (CS 2; $\kappa = .44$). Concordance between pairwise trajectories that used highly discrepant definitions was low (e.g., $\kappa = .07$ for CS 1 vs. CS 4).

Although describing agreement between trajectories is useful, it would be informative to understand the extent to which agreement is a function of particular combinations of courses (e.g., whether certain cells in each contingency table were particularly influential in contributing to agreement or disagreement). To examine this issue, we computed cell chi-squares for each of the cells in the contingency table. Significant cell chi-square values can reflect values greater than would be expected by chance (indicating that a particular combination of courses contribute to agreement) or lower than would be expected by chance (indicating that a particular combination of courses contribute to disagreement). However, presenting each of the 10 contingency tables would be cumber-some. Instead, we present a summary figure (see Figure 4) documenting the extent to which each of the cells contributed to agreement. Cell chi-square statistics for each cell were plotted on bar graphs for each of the 10 pairwise comparisons; hence, there are 10 bars for each cell. The height of each of the bars, thus, reflects deviation from chance (i.e., base rate) agreement between pairs of trajectories. As expected, corresponding courses (i.e., cells falling along the diagonal) were observed at a rate greater than would be expected by chance (represented by dark hatching), particularly for the chronic high and nondrinker groups, suggesting some stability in low drinking and in very heavy drinking. Level of agreement on the off-diagonal was consistently lower than chance agreement (represented by light hatching), particularly for comparisons with a non-HED class.

Three important off-diagonal associations are worth noting. First, those categorized as early onset increasers according to a less severe CS were likely to be categorized as later onset increasers according to a more severe CS, suggesting a somewhat lagged effect between less vs. more frequent HED. Second, those categorized in the chronic class according to a less severe CS were likely to be categorized as an early onset increaser according to a more severe CS, perhaps reflecting tolerance to alcohol that in turn brought about heavier drinking. Finally, those categorized in a chronic class according to a less severe CS score were also likely to be categorized in a decreasing class according to a more severe CS, indicating that the majority of individuals who continually drank heavily in low frequency were drinking with great frequency only during early college years, consistent with findings that those who have reached legal drinking age engage in less HED than do those who are underage.

Construct Validity

To determine which cut score was maximally associated with individual covariates, respondents were assigned to their most likely class, and dummy-coded class membership served as a predictor in a series of regression analyses for 11 criterion variables across trajectories based upon different cut scores. In all cases, examination of specific betas indicated that heavier drinking classes yielded higher scores on the correlates (e.g., men, those high on novelty seeking, and those with enhancement drinking motives were more likely to belong to heavy drinking groups). We examined proportion of variance accounted for after controlling for gender (see Table 3, columns labeled *Full*). Visual inspection of the R-square values suggests that the two lowest cut scores (any HED and HED at least two to three times in the past 30 days; CS 1 and CS 2) explained the greatest variance for most outcome measures, although gender and conduct disorder were most strongly associated with the highest cut score (CS 5).[2]

Next, we addressed the extent to which the association between the cut scores and the correlates was due to the distinction between those who do versus do not engage in HED. We conducted a final set of analyses that excluded those belonging to the non-HED group for a given cut score (see Table 3 columns labeled *Without non-HED*). R-square values were substantially attenuated, particularly for cut scores marked by frequent HED of 5+ drinks (CS 3 and CS 4). Although we are not aware of a simple, formal test by which we can identify variation that is due to (differences from) the non-HED class, it appears that there is some tendency for there to be more meaningful variation not associated with the abstaining class when lower thresholds are used.

Discussion

The goal of the present study was to examine the implications of different cut scores on the characterization of trajectories of HED, with consideration of prevalence rates, concordance, and associations with theoretical and clinical criteria. Although we were interested in exploring whether there was a single cut score that optimized meaningful variability in course, we recognize that any such cut score could be sample, stage of life, and criterion specific.

Across the five cut scores, we identified five trajectories that varied in age of onset (early vs. late), degree of change (increasing vs. decreasing), and severity (level) of use. These trajectories are consistent with Zucker’s (1994) conceptualization of subgroups of alcoholics based on both course and chronicity of alcohol dependence (e.g., developmentally limited, developmentally cumulative alcoholics) as well as with other researchers’ empirical work documenting heavy drinking trajectories (e.g., Chassin et al., 2002; Tucker et al., 2003; Windle et al., 2005), including a study that used a frequent heavy drinking cut score that corresponded to our CS 2 (5+ drinks at least two to three times in the past 30 days) (Schulenberg, O’Malley, et al., 1996; Schulenberg, Wadsworth, et al., 1996). These studies generally have identified a nonuser/low user course, a chronic high course, a decreasing course, and an escalating course. Our findings also are consistent with typologies that categorize individuals on the basis of alcohol use disorder severity (Type A vs. Type B: Babor et al., 1992; Type I vs. Type II: Cloninger, 1987a) and age of onset (Buydens-Branchey, Branchey, & Noumair, 1989; Lee & DiClimente, 1985). It is reassuring that a five-trajectory model was observed for each of the cut scores, consistent with our prior work showing similarity in cut scores using alternate indexes of alcohol involvement (Jackson & Sher, 2005).

Not unexpectedly, as the severity of a drinking cut score increased (e.g., increasingly frequent HED), individuals were increasingly categorized into less severe classes. This finding is almost tautological and requires no further consideration; however, it is important to bear in mind that an individual who is not categorized in an HED class based on a more severe cut score may still be engaging in some level of HED and, hence, may be at risk for adverse alcohol-related outcomes. When “frequent” HED is defined by three or more HED episodes per 2 weeks

[2]We are not aware of any statistical tests that would permit us to compare *R*-squares for different sets of variables (with four dummy codes reflecting the nominal class variable). Conceptually, this is an extension of the test for dependent correlations (e.g., Meng, Rosenthal, & Rubin, 1992), considering *R*-square rather than *r*. As such, we looked for trends in the association between increasingly severe cut scores and correlates.

(roughly corresponding to our CS 3), those who engage in frequent HED consume alcohol in quantities well beyond the 5+ to 4+ threshold (A. M. White et al., 2006), and the number of HED episodes in the past 2 weeks can far exceed three occasions (LaBrie et al., 2007).

As we anticipated, classes characterized by a change in HED over time were more nuanced when frequent HED was defined by a severe cut score: For CS 4, two separate groups whose drinking declined were observed, but this was not true for lower cut scores. Less severe cut scores tended to have greater resolution in identifying nonabstaining HED classes; lower cut scores tended to show greater separation of classes (i.e., greater area between the trajectories). As cut scores increase in severity, potentially meaningful patterns become subsumed in the non-HED class; correspondingly, the prevalences of HED classes become lower. The two most severe cut scores (CS 4 and CS 5) yielded chronic high groups with very low prevalences (3% and 2%, respectively), suggesting that these two cut scores may not be optimally capturing the maximum amount of heterogeneity in the HED course.

When we use highly discrepant definitions of what constitutes frequent HED, we observe strikingly low concordance between trajectories despite similar “looking” trajectory classes. When there was agreement, courses generated by different cut scores paralleled each other, either in a contemporaneous or a lagged fashion. Of interest given the limited work examining a very high heavy consumption threshold (12+ drinks), many individuals who reported drinking 5+ drinks on a frequent basis also reported consuming 12+ drinks per occasion.

Validity analyses based upon association with drinking-relevant criteria failed to identify a single cut score that was clearly superior to others, although in our analyses comparing the 12 + threshold with the 5+ threshold for HED, drinking behavior at the level of 12+ drinks per occasion seems to have clear clinical significance for women insofar as heavy drinking is associated with numerous adverse health consequences (e.g., unintentional injury; Smith, Branas, & Miller, 1999). The finding that that no single cut score outperformed the others suggests that general theories may hold regardless of how frequent heavy drinking is operationalized and that a parsimonious definition may be ideal (e.g., any HED vs. no HED). There was some evidence that the lowest cut scores (CS 1 and CS 2) explained the greatest variance for most outcome measures (and they certainly did no worse than other cut scores), suggesting that the frequent HED measure defined by three or more HED episodes in the prior 2-week period (corresponding to our CS 3) used by some researchers may in actuality be too severe to adequately capture much of the meaningful variability in a behavior of interest. Some interesting patterns emerged whereby less severe cut scores seemed to be associated with more normative items (e.g., enhancement motives), whereas more deviant behaviors were better discriminated by more severe cut scores (e.g., coping motives). Our findings must be considered preliminary given the descriptive nature of the analyses and the limited set of validity indicators. In addition, there is a tendency for there to be more meaningful variation not associated with the non-HED class when lower thresholds are used. If true, this is likely due to two reasons: (a) Base rates are higher for different HED trajectories when lower cut scores are used, and (b) using too severe a cut score potentially masks serious but subthreshold drinking.

Implications for Assessment and Intervention

The current work extends traditional cut score analyses to a developmental framework where determination of an optimal cut score was not simply based on a single measurement occasion but was set in the context of intraindividual patterning over time. Influential theorists have suggested that early alcohol involvement provides critical information for defining drinking typologies, and our findings clearly indicate that whether frequent HED is early onset versus late onset depends upon the cut score employed. This general principle of where to apply a threshold for problematic alcohol involvement extends to other domains, such as number of dependence symptoms (Langenbucher et al., 2004; Winters, Latimer, & Stinchfield, 1999), number of alcohol consequences that are meaningful, and number of drinks in a given period (Jackson, 2008).

Selection of a cut score will almost certainly depend on the goals of intervention; cutoff points that are optimal for one clinical decision are not necessarily optimal for another (Kendler, 1990), and cut scores should be meaningful and specific to different social and clinical decisions (Widiger & Samuel, 2005). Given that considerable risk for alcohol-related consequences exists at as low as one drink per day (Weitzman & Nelson, 2004), a very liberal cut score such as endorsement of any heavy drinking (CS 1) might be a suitable goal for universal prevention programs (e.g., alcohol intervention programs upon college entry). Indeed, our analyses suggest that traditional definitions of frequent heavy drinking (e.g., five or more occasions per month) represent too high a frequency threshold for identifying individuals who are likely to experience significant problems and exhibit chronic courses. Consequently, indicated prevention programs (e.g., mandated interventions to combat risky alcohol use) might target any individuals whose risky alcohol involvement is unlikely to remit. Because our findings indicate the relative nature of “remission,” clinicians should fully understand that clients can show a reduction in frequency of heavy drinking while still maintaining a chronic pattern likely to incur negative consequences. In general, the clinical relevance of various subtypes increases with increasing thresholds, but many individuals who were categorized as belonging to the non-HED class based on CS 3 or CS 4 are engaging in regular (e.g., more than once per month) HED and may still be of clinical concern. In any clinical prediction context, the choice of cut scores will be highly dependent on the relative costs and benefits of Type I and Type II errors (the relative importance of sensitivity vs. specificity for a given clinical or public health problem; Hurlbut & Sher, 1992). Perhaps the most useful clinical information to be gleaned from the trajectories derived in the present study concerns prognosis. The types of data reported here, if extended to populations beyond the present college student sample, could provide useful information concerning the likelihood of chronic versus remitting courses as a function of level (i.e., frequency) of HED. These actuarial predictions are useful both to clinicians and to clients who want to evaluate the potential value of intervention.

Implications for Research Using Trajectory-Based Modeling

Given the rise of trajectory-based approaches in characterizing the developmental course of alcohol involvement over the lifespan, it is critical for researchers to consider the practical implications of measurement and design issues on the identification and properties of empirically derived trajectories. The present study findings underscore the need for caution when interpreting the findings of an investigation and when synthesizing findings across multiple studies that employ different definitions of risky drinking. Although two sets of trajectory classes from two different studies may appear similar with regard to developmental course, the meaning of and membership in the classes can vary dramatically. These conclusions are consistent with and extend our prior work (Jackson & Sher, 2005, 2006) that examined methodological aspects of trajectory-based approaches to modeling course of alcohol use. These earlier investigations led us to conclude that trajectory membership is highly dependent upon the specific measures employed as well as on study design (i.e., participant age, frequency and timing of measurements). Despite a similar trajectory structure across models with varying methodological characteristics, agreement across trajectories was low. It is reassuring that in our prior work as well as in the present study that there was relatively high consistency in construct validation. On the basis of our programmatic work to date, we conclude that these types of mixture analyses, rather than “carving nature at her joints,” yield informative and useful taxonomies of individuals’ drinking careers that are highly method dependent. In general, these demonstrations, addressing practical design issues, have added to the discussion surrounding cautions in these techniques that have been raised by methodologists (e.g., Bauer & Curran, 2003; but see Cudeck & Henly, 2003; B. Muthén, 2003).

Conclusion

In conclusion, we established that alternate definitions of frequent HED yield developmental trajectories distinguished by differing points of onset and course shape and with markedly different prevalences. It is also clear that no single cut score is sufficient to characterize correlates of HED, and researchers must be thoughtful about their decision to identify criteria for extreme heavy drinking. We hope this study has shed some light on measurement issues in defining risky drinking and will extend our prior work characterizing the developmental course of alcohol involvement that highlights the method-dependent nature of longitudinal trajectories.

References

American Psychiatric Association. Diagnostic and statistical manual of mental disorders. Vol. 4th ed.. Author; Washington, DC: 1994.

Babor TF, Hofmann M, DelBoca FK, Hesselbrock V, Meyer RE, Dolinsky ZS, Rounsaville B. Types of alcoholics: I. Evidence for an empirically derived typology based on indicators of vulnerability and severity. Archives of General Psychiatry 1992;49:599–608. [PubMed: 1637250]

Bauer DJ, Curran PJ. Distributional assumptions of growth mixture models: Implications for over-extraction of latent trajectory classes. Psychological Methods 2003;8:338–363. [PubMed: 14596495]

Borsari B, Carey KB. Two brief alcohol interventions for mandated college students. Psychology of Addictive Behaviors 2005;19:296–302. [PubMed: 16187809]

Buydens-Branchey L, Branchey MH, Noumair D. Age of alcoholism onset: I. Relationship to psychopathology. Archives of General Psychiatry 1989;46:225–230. [PubMed: 2919951]

Chassin L, Pitts SC, Prost J. Binge drinking trajectories from adolescence to emerging adulthood in a high-risk sample: Predictors and substance abuse outcomes. Journal of Consulting and Clinical Psychology 2002;70:67–78. [PubMed: 11860058]

Cloninger CR. Neurogenetic adaptive mechanisms in alcoholism. Science April 24;1987a 236:410–416. [PubMed: 2882604]

Cloninger, CR. *Tridimensional Personality Questionnaire* (Version 4). 1987b. Unpublished manuscript

Cohen J. A coefficient of agreement for nominal scales. Educational Psychological Measurement 1960;20:37–46.

Cooper ML. Motivations for alcohol use among adolescents: Development and validation of a four-factor model. Psychological Assessment 1994;6(2):117–128.

Cudeck R, Henly SJ. A realistic perspective on pattern representation in growth data: Comment on Bauer and Curran (2003). Psychological Methods 2003;8:378–383. [PubMed: 14596498]

Ellickson PL, McGuigan KA, Adams V, Bell RM, Hays RD. Teenagers and alcohol misuse in the United States: By any definition, it's a big problem. Addiction 1996;91:1489–1504. [PubMed: 8917917]

Engs RC, Diebold BA, Hanson DJ. The drinking patterns and problems of a national sample of college students. Journal of Alcohol & Drug Education 1996;41:13–33.

Graham K, Demers A, Rehm J. Problems with the graduated frequency approach to measuring alcohol consumption: Results from a pilot study in Toronto, Canada. Alcohol and Alcoholism 2004;39:455–462. [PubMed: 15289203]

Graham K, Massak A, Demers A, Rehm J. Does the association between alcohol consumption and depression depend on how they are measured? Alcoholism: Clinical and Experimental Research 2007;31:78–88.

Greenfield TK, Midanik LT, Rogers JD. A 10-year national trend survey of alcohol consumption, 1984-1995: Is the period of declining drinking over? American Journal of Public Health 2000;90:47–52. [PubMed: 10630136]

Hilton ME. Drinking patterns and drinking problems in 1984: Results from a general population survey. Alcoholism: Clinical and Experimental Research 1987;11:167–175.

Hilton, ME. Demographic characteristics and the frequency of heavy drinking as predictors of self-reported drinking problems. In: Clark, WB.; Hilton, ME., editors. Alcohol in America: Drinking practices and problems. State University of New York; Albany, NY: 1991. p. 194-212.

Hurlbut SC, Sher KJ. Assessing alcohol problems in college students. Journal of American College Health 1992;41:49–58. [PubMed: 1460173]

Jackson KM. Heavy episodic drinking: Determining the predictive utility of five or more drinks. Psychology of Addictive Behaviors 2008;22

Jackson KM, Sher KJ. Similarities and differences of longitudinal phenotypes across alternate indices of alcohol involvement: A methodologic comparison of trajectory approaches. Psychology of Addictive Behaviors 2005;19:339–351. [PubMed: 16366806]

Jackson KM, Sher KJ. Comparison of longitudinal phenotypes based on number and timing of assessments: A systematic comparison of trajectory approaches II. Psychology of Addictive Behaviors 2006;20:373–384. [PubMed: 17176172]

Jones BL, Nagin DS, Roeder KA. SAS procedure based on mixture models for estimating developmental trajectories. Sociological Methodology Research 2001;29:374–393.

Kendler KS. Toward a scientific psychiatric nosology: Strengths and limitations. Archives of General Psychiatry 1990;47:969–973. [PubMed: 2222134]

Knight JR, Wechsler H, Kuo M, Seibring M, Weitzman ER, Schuckit MA. Alcohol abuse and dependence among U.S. college students. Journal of Studies on Alcohol 2002;63:263–270. [PubMed: 12086126]

Krueger RF, Watson D, Barlow DH. Introduction to the special section: Toward a dimensionally based taxonomy of psychopathology. Journal of Abnormal Psychology 2005;114:491–493. [PubMed: 16351372]

LaBrie JW, Pedersen ER, Tawalbeh S. Classifying risky-drinking college students: Another look at the two-week drinker-type categorization. Journal of Studies on Alcohol and Drugs 2007;68:86–90. [PubMed: 17149521]

Langenbucher JW, Labouvie E, Martin CS, Sanjuan PM, Bavly L, Kirisci L, Chung T. An application of item response theory analysis to alcohol, cannabis, and cocaine criteria in *DSM-IV*. Journal of Abnormal Psychology 2004;113:72–80. [PubMed: 14992659]

Lee GP, DiClimente CC. Age of onset vs. duration of problem drinking on the Alcohol Use Inventory. Journal of Studies on Alcohol 1985;46:398–402. [PubMed: 4068719]

Lo Y, Mendell NR, Rubin DB. Testing the number of components in a normal mixture. Biometrika 2001;88:767–778.

McLachlan, G.; Peel, D. Finite mixture models. Wiley; New York: 2000.

Meng, X-L.; Rosenthal, R.; Rubin, DB. Psychological Bulletin. Vol. 111. 1992. Comparing correlated correlation coefficients; p. 172-175.

Muthén, B. Second-generation structural equation modeling with a combination of categorical and continuous latent variables: New opportunities for latent class-latent growth modeling. In: Collins, LM.; Sayer, AG., editors. New methods for the analysis of change: A decade of behavior. American Psychological Association; Washington, DC: 2001. p. 291-322.

Muthén B. Statistical and substantive checking in growth mixture modeling: Comment on Bauer and Curran (2003). Psychological Methods 2003;8:369–377. [PubMed: 14596497]

Muthén, B. Latent variable analysis: Growth mixture modeling and related techniques for longitudinal data. In: Kaplan, D., editor. Handbook of quantitative methodology for the social sciences. Sage; Newbury Park, CA: 2004. p. 345-368.

Muthén B, Muthén LK. Integrating person-centered and variable-centered analyses: Growth mixture modeling with latent trajectory classes. Alcoholism: Clinical and Experimental Research 2000;24:882–891.

Muthén, LK.; Muthén, BO. Mplus User's Guide. Vol. 4th ed.. Author; Los Angeles: 19982006.

Nagin DS. Analyzing developmental trajectories: A semiparametric, group-based approach. Psychological Methods 1999;4:139–157.

Nagin DS, Tremblay RE. Developmental trajectory groups: Fact or a useful statistical tradition? Criminology 2005;43:873–904.

National Institute on Alcohol Abuse and Alcoholism. NIAAA council approves definition of binge drinking. NIAAA Newsletter; 2004. Retrieved September 23, 2005, from http://pubs.niaaa.nih.gov/publications/Newsletter/winter2004/Newsletter_Number3.htm

Oesterle S, Hill KG, Hawkins JD, Guo J, Catalano RF, Abbott RD. Adolescent heavy episodic drinking trajectories and health in young adulthood. Journal of Studies on Alcohol 2004;65:204–212. [PubMed: 15151351]

Roeder K, Lynch K, Nagin DS. Modeling uncertainty in latent class membership: A case study in criminology. Journal of the American Statistical Association 1999;94:766–776.

Schulenberg J, O'Malley PM, Bachman JG, Wadsworth KN, Johnston LD. Getting drunk and growing up: Trajectories of frequent binge drinking during the transition to young adulthood. Journal of Studies on Alcohol 1996;57:289–304. [PubMed: 8709588]

Schulenberg J, Wadsworth KN, O'Malley PM, Bachman JG, Johnston LD. Adolescent risk factors for binge drinking during the transition to young adulthood: Variable- and pattern-centered approaches to change. Developmental Psychology 1996;32:659–674.

Schwarz G. Estimating the dimension of a model. Annals of Statistics 1978;6:461–464.

Sher KJ, Rutledge PC. Heavy drinking across the transition to college: Predicting first-semester heavy drinking from precollege variables. Addictive Behaviors 2007;32:819–835. [PubMed: 16860940]

Sher KJ, Wood M, Crews T, Vandiver TA. The Tridimensional Personality Questionnaire: Reliability and validity studies and derivation of a short form. Psychological Assessment 1995;7:195–208.

Smith GS, Branas CC, Miller TR. Fatal non-traffic injuries involving alcohol: A meta-analysis. Annals of Emergency Medicine 1999;33:659–668. [PubMed: 10339681]

Tucker JS, Orlando M, Ellickson PL. Patterns and correlates of binge drinking trajectories from early adolescence to young adulthood. Health Psychology 2003;22:79–87. [PubMed: 12558205]

Wechsler H, Austin SB. Binge drinking: The five/four measure. Journal of Studies on Alcohol 1998;59:122–123. [PubMed: 9498324]

Wechsler H, Davenport A, Dowdall G, Moeykens B, Castillo S. Health and behavioral consequences of binge drinking in college: A national survey of students at 140 campuses. Journal of the American Medical Association 1994;272:1672–1677. [PubMed: 7966895]

Wechsler H, Dowdall GW, Maenner G, Gledhill-Hoyt J, Lee H. Changes in binge drinking and related problems among American college students between 1993-1997. Journal of American College Health 1998;47:57–68. [PubMed: 9782661]

Wechsler H, Lee JE, Kuo M, Seibring M, Nelson TF, Lee H. Trends in college binge drinking during a period of increased prevention efforts. Journal of American College Health 2002;50:203–217. [PubMed: 11990979]

Wechsler H, Nelson TF. Binge drinking and the American college student: What's five drinks? Psychology of Addictive Behaviors 2001;15:287–291. [PubMed: 11767258]

Weitzman ER, Nelson T. College student binge drinking and the "prevention paradox": Implications for prevention and harm reduction. Journal of Drug Education 2004;34:247–265. [PubMed: 15648886]

White AM, Kraus CL, Swartzwelder HS. Many college freshmen drink at levels far beyond the binge threshold. Alcoholism: Clinical and Experimental Research 2006;30:1006–1010.

White HR, Jackson KM. Social and psychological influences on emerging adult drinking behavior. Alcohol, Research, and Health 20042005;28:182–190.

Widiger TA, Clark LA. Toward *DSM-V* and the classification of psychopathology. Psychological Bulletin 2000;126:946–963. [PubMed: 11107884]

Widiger TA, Samuel DB. Diagnostic categories or dimensions? A question for the Diagnostic and Statistical Manual of Mental Disorders—Fifth Edition. Journal of Abnormal Psychology 2005;114:494–504. [PubMed: 16351373]

Windle M, Mun EY, Windle RC. Adolescent-to-young adulthood heavy drinking trajectories and their prospective predictors. Journal of Studies on Alcohol 2005;66:313–322. [PubMed: 16047520]

Winters K, Latimer W, Stinchfield R. The *DSM-IV* criteria for adolescent alcohol and cannabis use disorders. Journal of Studies on Alcohol 1999;60:337–344. [PubMed: 10371261]

World Health Organization. International guide for monitoring alcohol consumption and related harm. Author; Geneva, Switzerland: 2000. Publication No. WHO/MSD/MSB/00.4

Zucker, RA. Pathways to alcohol problems and alcoholism: A developmental account of the evidence for multiple alcoholisms and for contextual contributions to risk. In: Zucker, RA.; Howard, J.; Boyd, GM., editors. The Development of Alcohol Problems: Exploring the Biopsychosocial Matrix of Risk. National Institute on Alcohol Abuse and Alcoholism; Rockville, MD: 1994. p. 255-289.

NIH-PA Author Manuscript

NIH-PA Author Manuscript

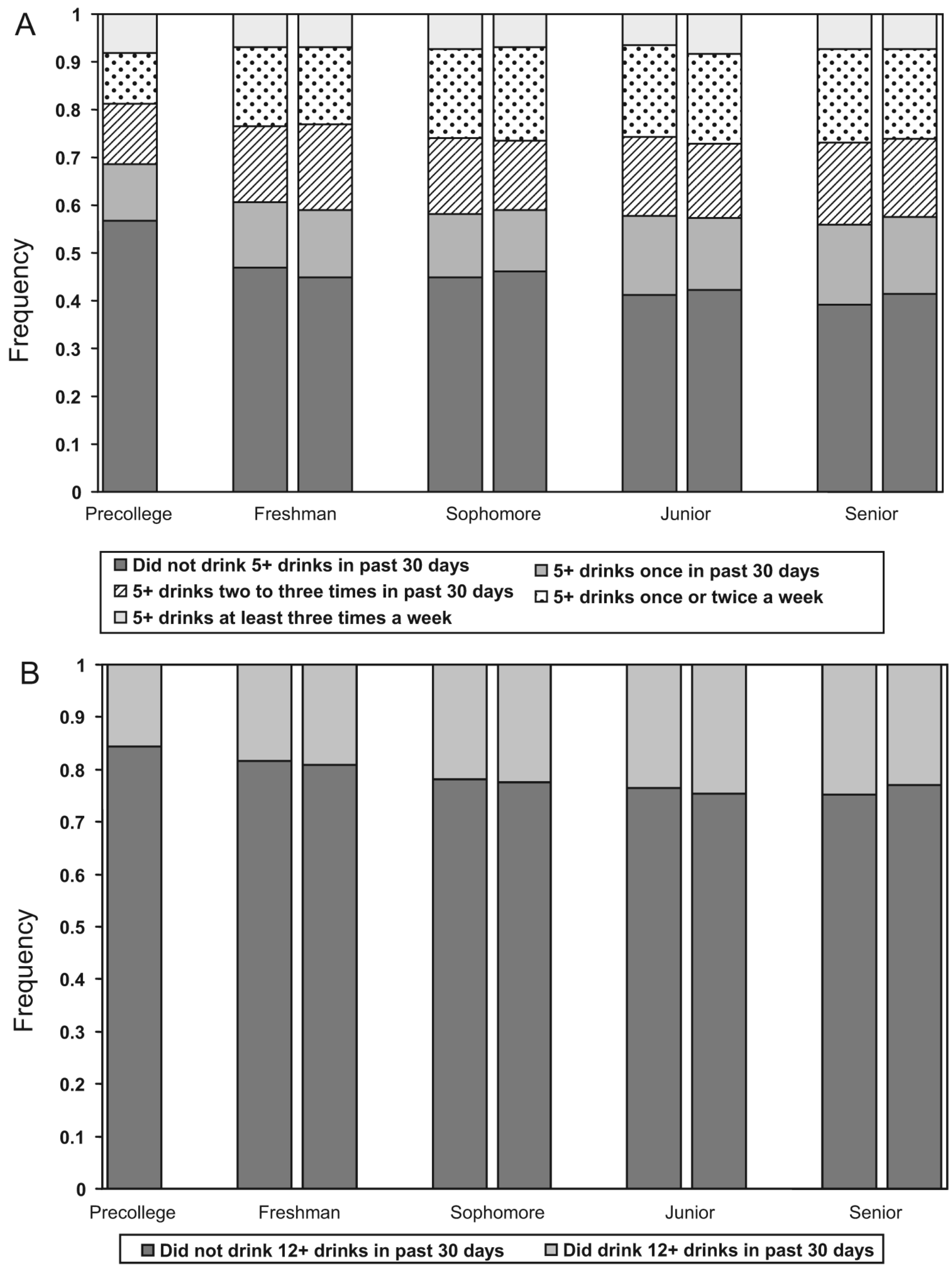

Figure 1.

Proportion endorsing heavy episodic drinking options at the precollege assessment (Wave 0) and each semester of college (Waves 1-8). A: Frequency of drinking 5+ drinks per occasion. B: Frequency of drinking 12+ drinks per occasion. *N* ranges from 2,140 (Wave 8) to 3,054 (Wave 0).

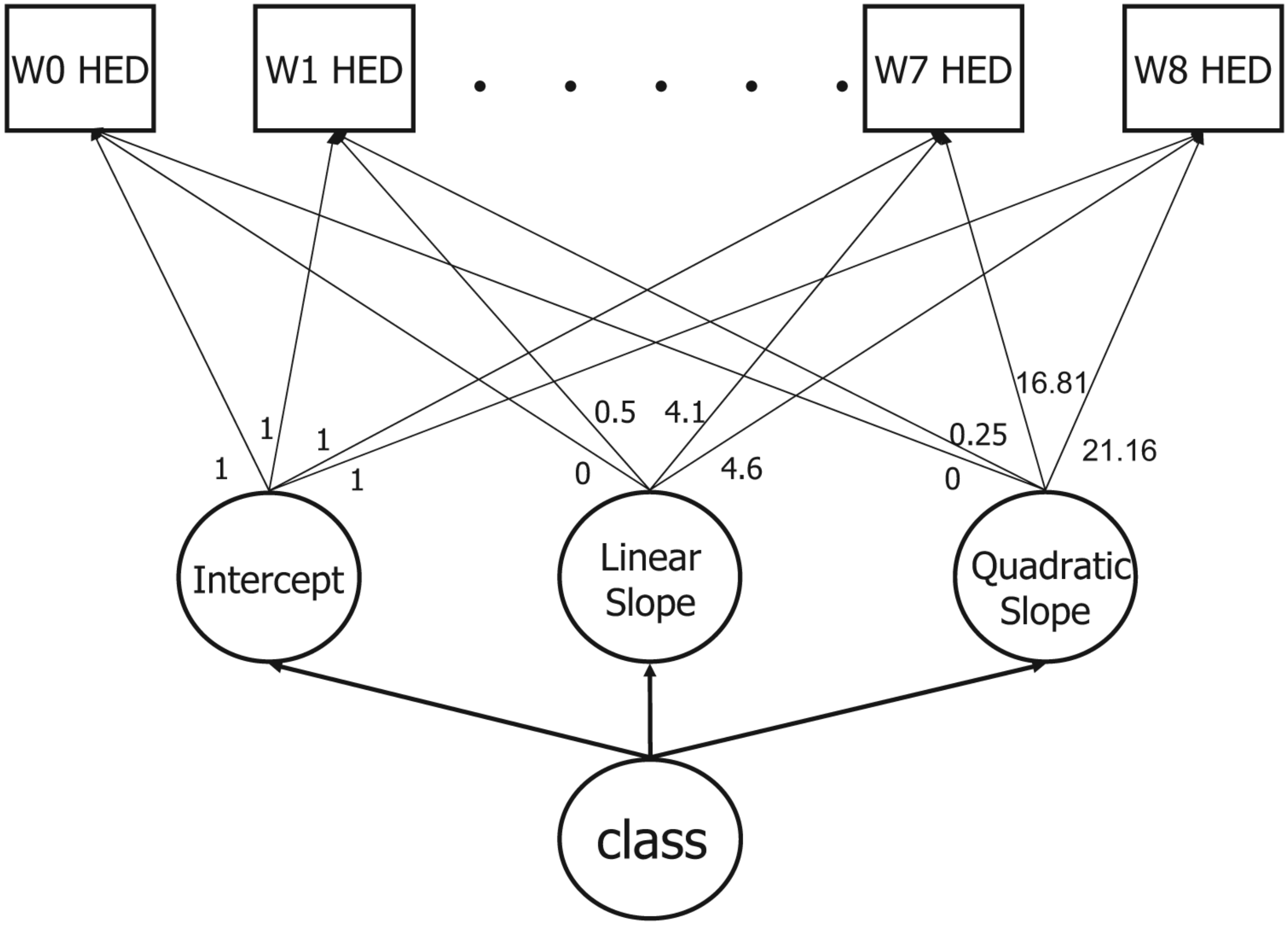

Figure 2.
Figure depicting the latent growth model underlying the latent class growth analysis for characterizing trajectories of heavy alcohol use. Factor loadings were set according to the interval between assessments (in months). For the linear slope factor, the loadings were fixed to 0, 0.5, 1.0, 1.7, 2.2, 2.9, 3.4, 4.1, and 4.6 at Waves 0 through 8, respectively. For the quadratic slope factor, the loadings were fixed to 0, 0.25, 1.0, 2.89, 4.84, 8.41, 11.56, 16.81, and 21.16 at Waves 0 through 8, respectively. Correlations between intercept and linear and quadratic slope factors were estimated but are not presented in the figure. W = wave; HED = heavy episodic drinking.

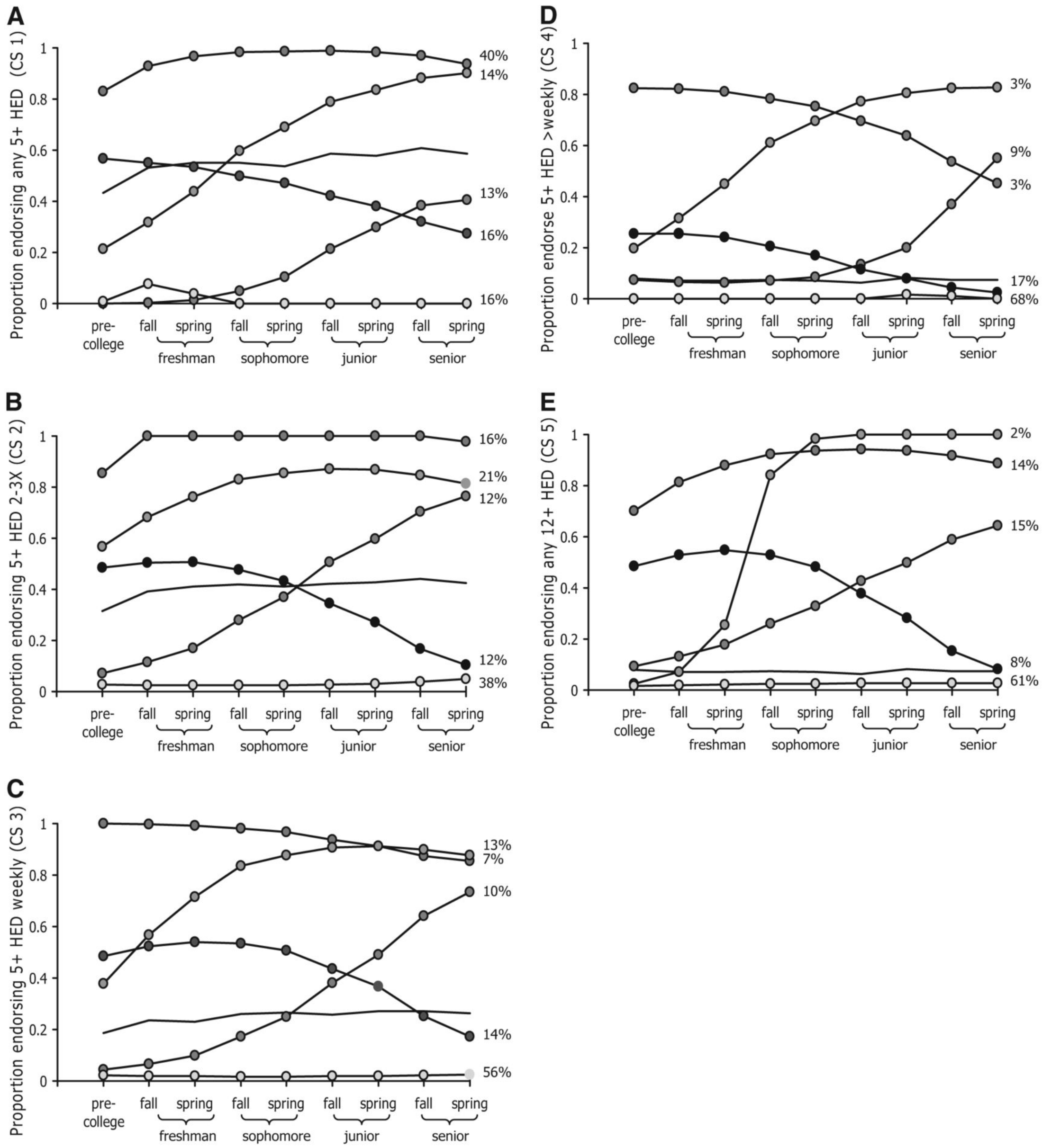

Figure 3.

Latent class growth analysis models for five cut scores of frequent binge drinking, weighted by estimated class probabilities. The panels correspond to the five frequent heavy episodic drinking (HED) cut scores (CS). A: Drinking 5+ drinks at least once in the past 30 days. B: Drinking 5+ drinks at least two to three times in the past 30 days. C: Drinking 5+ drinks at least once or twice a week. D: Drinking 5+ drinks at least three times a week. E: Drinking 12 + drinks at least once in the past 30 days. *N* = 3,058.

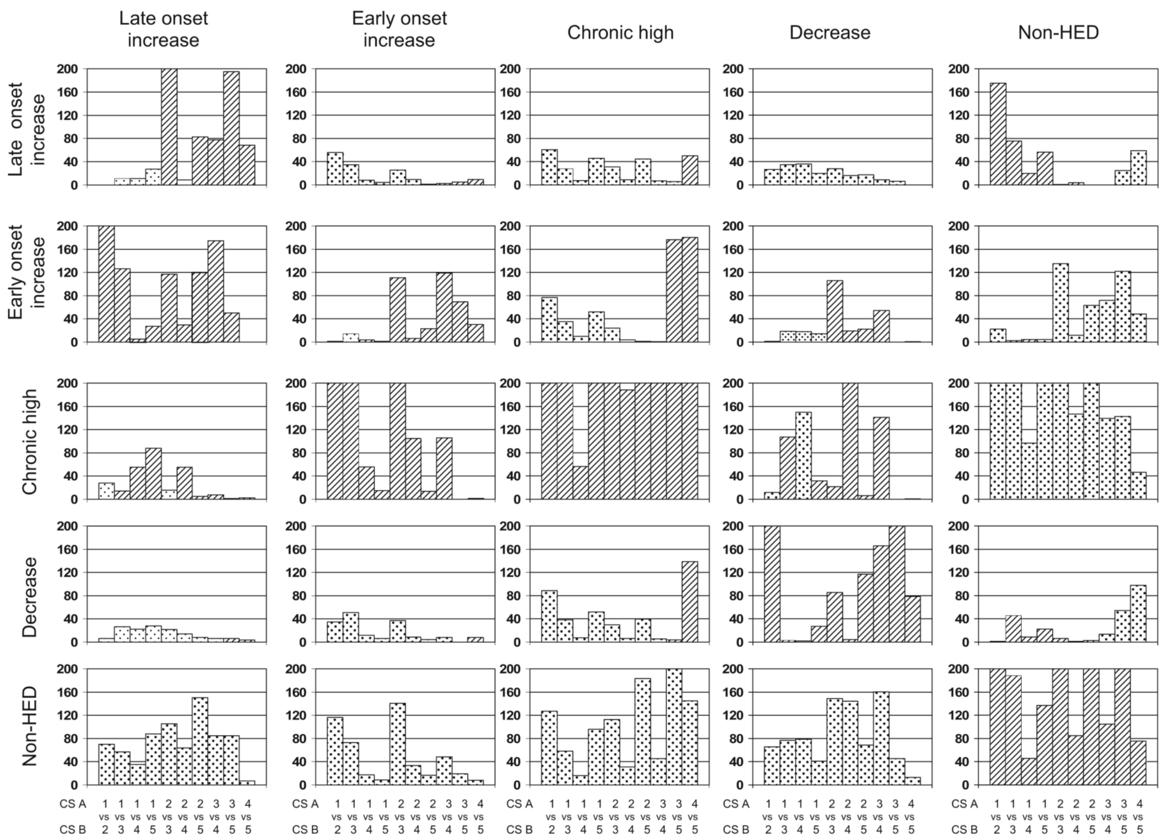

Figure 4.

(opposite). Summary of trajectory agreement represented by cell chi-square values (as indicated on the *y*-axis) for each of the heavy episodic drinking (HED) cut scores (CS). Agreement reflects the association between a given CS A and CS B; particular combinations are noted in the legends beneath each column of bar graphs. Dark hatching reflects cell chi-square values that are greater than would be expected by chance, and light coloring indicates cell chi-square values that are lower than would be expected by chance, based on the marginals. To retain meaningful scaling, any cell chi-square statistic that exceeded 200 was graphed at 200. Note that a chi-square value with a single degree of freedom of 3.84 is significant at $p < .05$, and a chi-square value with a single degree of freedom of 6.64 is significant at $p < .01$.

Table 1

Fit Indexes and Likelihood Ratio Tests for Relative Improvement in Fit for Heavy Episodic Drinking (HED) Cut Scores (CS)

No. of classes	Test of model fit	Frequent HED cut score: 5+ drinks at least once in past 30 days (CS 1)	5+ drinks at least two to three times in past 30 days (CS 2)	5+ drinks at least once or twice a week (CS 3)	5+ drinks at least three times a week (CS 4)	12+ drinks at least once in past 30 days (CS 5)
1	BIC	29,518.44	28,979.01	23,993.92	11,340.16	22,188.07
2	BIC	21,331.65	20,779.26	17,332.37	9,454.52	16,210.59
	VLMR LR	$p < .0001$	$p < .0001$	$p < .0001$	$p < .0001$	$p < .0001$
3	BIC	20,456.30	19,959.28	16,836.65	9,342.84	15,745.56
	VLMR LR	$p < .0001$	$p < .0001$	$p < .0001$	$p < .0006$	$p < .0001$
4	BIC	20,234.92	19,766.76	16,655.40	9,292.17	15,619.42
	VLMR LR	$p < .0001$	$p < .0001$	$p < .0001$	$p = .0030$	$p < .0001$
5	BIC	20,156.07	19,742.25	16,646.46	9,291.61	15,610.65
	VLMR LR	$p < .0001$	$p = .0001$	$p = .0021$	$p = .0192$	$p = .0005$
6	BIC	20,131.65	19,731.14	16,643.87	9,304.13	15,600.71
	VLMR LR	$p = .0110$	$p < .0001$	$p = .0338$	$p = .0311$	$p = .1821$
7	BIC	20,126.52	19,732.01	16,659.19	9,328.28	15,449.20
	VLMR LR	$p = .5235$	$p = .0293$	$p = .2429$	—[a]	$p = .1544$

Note. N = 3,058. BIC = Bayesian information criterion; VLMR LR = Vuong-Lo-Mendell-Rubin likelihood ratio test for k versus $k + 1$ classes (not applicable when there is only one class).

[a] Solution for this likelihood ratio test would not converge.

Table 2

Comparison of Trajectories Using Cramer's V and Cohen's Kappa (κ)

Cut score (CS)	1	2	3	4	5
1. 5+ drinks at least once in past 30 days (CS 1)	—	.55	.40	.25	.35
2. 5+ drinks at least two to three times in past 30 days (CS 2)	.36	—	.51	.31	.43
3. 5+ drinks at least once or twice a week (CS 3)	.16	.44	—	.41	.44
4. 5+ drinks at least three times a week (CS 4)	.07	.18	.37	—	.33
5. 12+ drinks at least once in past 30 days (CS 5)	.20	.39	.47	.31	—

Note. $N = 3{,}058$. Cramer's V statistics are shown above the diagonal; Cohen's kappa statistics are shown below the diagonal.

Table 3

Proportion of Variance Accounted for (R-Square) by Class Membership Defined by Alternate Cut Scores Across External Validity Correlates for the Full Sample and for the Sample Excluding Non-HED for That Cut Score, Controlling for Gender

		Frequent heavy episodic drinking (HED) cut score (CS)									
		5+ drinks at least once in past 30 days (CS 1)		5+ drinks at least two to three times in past 30 days (CS 2)		5+ drinks at least once or twice a week (CS 3)		5+ drinks at least three times a week (CS 4)		12+ drinks at least once in past 30 days (CS 5)	
External validity correlate	N^a	Full	Without non-HED	Full	Without non-HED	Full	Without non-HED	Full	Without non-HED	Full	Without non-HED
Gender[b]	3,058	.06	.05	.08	.06	.08	.03	.05	.04	.22	.15
Conduct disorder (< age 15)	2,625	.03	.02	.04	.02	.04	.03	.05	.02	.05	.03
Wave 1: Novelty seeking	2,550	.08	.05	.08	.04	.07	.04	.05	.02	.06	.03
Wave 7: Novelty seeking	2,184	.06	.02	.06	.02	.05	.03	.04	.02	.06	.01
Wave 1: Greek member status	2,442	.14	.09	.13	.05	.12	.03	.07	.05	.09	.04
Wave 0: Coping RFD	2,105	.08	.05	.10	.05	.09	.04	.06	.01	.08	.03
Wave 7: Coping RFD	2,071	.09	.05	.09	.02	.08	.01	.06	.03	.07	.04
Wave 0: Enhancement RFD	2,094	.22	.15	.24	.12	.19	.10	.10	.04	.12	.08
Wave 7: Enhancement RFD	2,073	.22	.10	.20	.04	.14	.05	.08	.02	.09	.03
Wave 0: Alcohol consequences	3,035	.38	.29	.42	.24	.39	.25	.27	.13	.32	.19
Wave 8: Alcohol consequences	2,108	.31	.19	.33	.15	.31	.09	.20	.07	.25	.12

[a]Sample sizes vary because of attrition from Waves 0 and 1 to Waves 7 and 8. Sample sizes are reduced for the reasons for drinking (RFD) measures because they were assessed only for participants who indicated they were “drinkers.” The sample size for analyses that exclude non-HED on a given cut score range from 440 to 2,420 (with smaller samples as cut scores increase in severity).

[b]Likelihood-based pseudo-rescaled *R*-square because gender is a dichotomous item (*female* = 0, *male* = 1).