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Analysis of Item Response and Differential Item Functioning of Alcohol Expectancies in Middle School Youth

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Abstract

Drinking behavior in pre-adolescence is a significant predictor of both short and long-term negative consequences. This study examined the psychometric properties of one known risk factor for drinking in this age group, alcohol expectancies, within an Item Response Theory framework. In a sample of middle school youth ($N = 1273$), we tested differential item functioning (DIF) in positive and negative alcohol expectancies across grade, gender, and ethnicity. MIMIC model analyses tested differences in alcohol use as a potential explanation for observed DIF across groups. Results showed that most expectancy items did not exhibit DIF. For items where DIF was indicated, differences in alcohol use did not explain differences in item parameters. Positive and negative expectancies also systematically differed in the location parameter. Latent variable scale scores of both positive and negative expectancies were associated with drinking behavior cross-sectionally, while only positive expectancies predicted drinking prospectively. Improving the measurement of alcohol expectancies can help researchers better assess this important risk factor for drinking in this population, particularly the identification of those with either very high positive or very low negative alcohol expectancies.

Keywords

Drinking; Alcohol; Expectancies; Children; Item Response Theory

Alcohol use in elementary and middle school aged youth represents a significant societal problem. Thirty-nine percent of U.S. 8th graders report lifetime alcohol use, while 16% report past month drinking and 5.5% report drinking to intoxication (Johnston, O'Malley, Bachman, & Schulenberg, 2007). Alcohol use during adolescence is associated with increased likelihood of an alcohol use disorder in young adulthood (e.g., D'Amico, Ellickson, Wagner et al., 2005; DeWit, Adlaf, Offord, & Ogborne, 2000; Grant & Dawson, 1997). It is important, therefore, to accurately assess risk factors for both the initiation and severity of alcohol use in young children. The current study sought to improve the measurement of one well established

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risk factor, alcohol outcome expectancies (Goldman, Darkes, & Del Boca, 1999; Jones, Corbin, & Fromme, 2001), for use with middle school participants.

Alcohol expectancies develop prior to experience with drinking and can be reliably identified in young children (Miller, Smith, & Goldman, 1990; Dunn & Goldman, 2000). Children as young as 3 years old hold schemas about alcohol and these schemas predict early initiation of drinking (Zucker, Kincaid, Fitzgerald, & Bingham, 1995). Young children have been found to hold largely negative expectancies about alcohol (Johnson & Johnson, 1995), while positive expectancies increase with age (Miller et al., 1990). However, there is some evidence that negative expectancies also increase across early adolescence (Cameron, Stritzke, & Durkin, 2003). Alcohol expectancies have been found to longitudinally predict onset of drinking in middle school youth (Simons-Morton, 2004).

In the present study, we used a two parameter Item Response Theory model to examine item discrimination (slope) and difficulty (location) of positive and negative alcohol expectancies. Item slope indicates the item's ability to identify changes in level of the latent trait. Item location indicates the probability of item endorsement at different levels of the latent trait. Most measures of alcohol expectancies were constructed based on principles of classical test theory (e.g., Brown et al., 1980; Fromme et al., 1993), and most psychometric investigations of these scales have been based on this framework. Classical test theory methods focus on increasing inter-item associations, which would be reflected in item slope. However, item difficulty is not assessed in classical test theory methods. Little is known, therefore, about the difficulty of alcohol expectancy items and their distribution across the range of the latent trait.

IRT models also allow for the assessment of differential item functioning (DIF) across groups. DIF exists when the performance of an item at a given level of the latent trait differs as a function of group membership. DIF does not necessarily indicate item bias, as it only indicates that item parameters differ across groups, which may be the result of actual differences across groups (Nunnally & Bernstein, 1994). In the present study, we tested DIF across grade, gender, and racial/ethnic group. Prior studies using confirmatory factor analysis have identified a lack of measurement invariance in positive alcohol expectancies between fourth and ninth graders (Schell, Martino, Elickson, Collins, & McCaffrey, 2005). Findings for gender differences in alcohol expectancies have been inconsistent (Brown, Goldman, Inn, & Anderson, 1980; Lundahl, Davis, Adesso, & Lukas, 1997). Studies have demonstrated expectancy differences between African American and Caucasians, with higher levels of positive expectancies in Caucasian adolescents (Slutske, Cronk, Madden, Bucholz, Sher, & Heath, 2002) and young adults (McCarthy, Miller, Smith, & Smith, 2001). In contrast, a study of young children found that African American children had higher expectancies that alcohol influences arousal/aggression compared to Caucasian children (Corvo, 2000).

In the assessment of alcohol expectancies, one issue in comparing item performance across groups is group differences in alcohol use. For example, older youth are more likely to be drinkers than younger adolescents, which might result in item parameter differences for alcohol expectancy items across groups. In the present study, we used Multiple Indicators, Multiple Causes (MIMIC; MacIntosh & Hashim, 2003) models to test whether observed DIF is best explained by group status or by differences in drinking across groups. Data for this study were collected as part of a larger intervention project, where one of the two middle schools in the study received an alcohol-related intervention. In order to test potential effects of the intervention on study results, we used MIMIC models to test whether DIF differed between the two middle schools involved in the study.

Finally, we estimated positive and negative expectancy latent trait scores (theta) using the derived item-response parameters, and tested the association of these scores with drinking

behavior cross-sectionally and over the course of one academic year. Latent trait scores for positive and negative expectancies were estimated with and without items that exhibited DIF in order to examine potential effects of item functioning on expectancy-drinking associations.

Method

Data were collected from sixth, seventh, and eighth graders ($N = 1310$) from two middle schools in California in November and May of a single school year, during Year 2 of a 3-year intervention study (D'Amico & Edelen, 2007). The sample was 47% male, with a mean age of 12.07 ($SD = .94$). Approximately 35% were White, 32% Latino, 7% Asian American/Pacific Islander, 4% African American, 12% identified themselves as mixed ethnic origin, and 9% identified themselves as "other".

Materials and procedures were approved by the Human Subjects Protection Committee at the investigating institution, the school district, and individual schools. Students were surveyed when normal absentee rates were expected ($< 5\%$), with no school vacation (e.g., spring break) in the preceding month (D'Amico, 2005). Students participated if parents returned a consent form, with 79% returning signed forms. Students completed written assent statements. Surveys were completed during a required PE class. Trained proctors from RAND described the survey, reviewed confidentiality, and answered questions. Responses were protected by a Certificate of Confidentiality from the National Institute of Health. Students answered survey questions on Scantron forms. Students who did not to participate attended their regular PE class.

Measures

Background questions—Background questions included age, grade, gender, and ethnicity.

Drinking Behaviors—Items from Monitoring the Future (Johnston, O'Malley, & Bachman, et al., 2007) and the Customary Drinking and Drug Use Record (Brown et al., 1998) were used to assess past 30 day frequency of drinking (Likert-style scale, range 0-4), frequency of heavy drinking (5 or more drinks at one time; frequency count, range 0-15), quantity (average number of drinks, range 0-15), and largest number of drinks at one time (largest quantity consumed, number of drinks, range 0-15).

B-CEOA—The CEOA is a well established measure of alcohol outcome expectancies. The full CEOA has 38 expectancy items, which have been found to load on two higher order factors of positive and negative expectancies (Fromme, Stroot, & Kaplan, 1993). The CEOA has demonstrated good test-retest and internal consistency reliability, and has been found to be associated with alcohol use in adolescent and college student populations (Fromme & D'Amico, 2000; Fromme et al., 1993). The B-CEOA is a 15 item short form of the CEOA (Ham, Stewart, Norton, & Hope, 2005). In a sample of college students, correlations between the B-CEOA with drinking behavior have been found to be comparable to those of the full scale (Ham et al., 2005). Despite their brevity, internal consistency reliability for the B-CEOA positive and negative expectancy scales is very good (positive $\alpha = .90$; negative $\alpha = .85$; Hatzenbuehler, Corbin, & Fromme, 2008). Two items from the B-CEOA assessing expectancies about alcohol's effect on sexual behavior (i.e., "I would be a better lover"; "I would enjoy sex more") were deemed inappropriate for use in middle school samples and were not included in the present study.

Matching Information and Missing Value Imputation

To maintain confidentiality, no identifying information was collected from participants. For prospective analyses, participants were matched from time 1 to time 2 using immutable characteristics (e.g., first letter of mother's first name) to create a unique identifier for each

participant, a procedure used in prior studies (D'Amico et al., 2005; D'Amico & McCarthy, 2006; Stice, Myers, & Brown, 1998). Of the 1310 participants at time 1, 47 were dropped due to inaccurate/random responding or duplicate identifiers. Of the remaining participants (1273), 70% were matched at both time points.

Matched participants were compared to the remainder of the sample on demographic and substance use characteristics. Unmatched participants were more likely to be male ($X^2(1, N = 1273) = 6.56, p < .01$), in 8th grade ($X^2(2, N = 1273) = 21.62; p < .01$), and African American or "other" ethnicity ($X^2(5, N = 1268) = 20.54, p < .01$). Unmatched youth also reported higher levels of past month alcohol use (frequency: $t(1271) = 4.78, p < .01, d = .27$; quantity: $t(1271) = 5.65, p < .01, d = .30$; frequency of heavy drinking: $t(1271) = 5.60, p < .01, d = .62$; largest drinks: $t(1271) = 6.46, p < .01, d = .34$).

A small percentage of missing values (1-3%) were found for some variables. A hot deck imputation method (Brick & Kalton, 1996) was used to impute missing data for B-CEOA and drinking behavior items. Missing data on demographic variables (e.g., age, ethnicity) was not imputed.

Plan of analyses

IRT analyses were conducted using Parscale 4.1 (Scientific Software International, Inc., 2003). Analyses were conducted using Samejima's Graded Response model (Samejima, 1969) designed for use with polytomous data (e.g., Likert-style scales). We first tested DIF of positive and negative expectancy items of the B-CEOA using a two step procedure. First, DIF was examined using the IRT likelihood ratio test (Thissen, Steinberg, & Gerrard, 1986). This test examines the loss in model fit when item parameters are constrained to be equal across groups. DIF was tested across grade, gender, and ethnicity. In each case, the largest group was used as the reference group (i.e., 6th grade, female, Caucasian). For ethnicity, DIF analyses were conducted across three groups, Caucasian, Latino, and all other ethnicities combined. Given the large number of comparisons, a p -value of .01 was used for these tests.

For items identified as demonstrating DIF by the IRT likelihood ratio test, we then used a MIMIC model approach to testing DIF (MacIntosh & Hashim, 2003) using Mplus 5.1 (Muthén & Muthén, 2008). MIMIC models are useful for testing the contribution of both measurement variables (e.g., scale items) and exogenous variables (e.g., demographic characteristics) to a latent variable. MIMIC model parameters have been found to be approximately equivalent to IRT parameters obtained from IRT software programs (MacIntosh & Hashim, 2003). Testing DIF using MIMIC models involves estimating a latent variable with categorical indicators, and regressing a group status variable (e.g., gender) on both the latent variable and the item to be tested for DIF. A significant path from the group variable to the item indicates DIF. One advantage of MIMIC model tests of DIF is that they allow for testing potential covariates that might explain DIF across groups. For items demonstrating DIF, we examined drinking behavior and school (intervention vs. control) as potential contributors to DIF.

We then estimated slope and item parameters for each item as well as the latent scale scores (theta) for positive and negative expectancy scales. Marginal Maximum Likelihood was used to estimate item parameters, with a Bayesian expected a posteriori method (Block & Aitkin, 1981) for estimating latent trait scores. We then tested associations between positive and negative expectancy latent trait scores and drinking behaviors both cross-sectionally and prospectively. We tested both bivariate and unique associations between expectancies and drinking at time 1. Time 1 drinking and school were included as covariates in prospective analyses. Log transformations were performed on alcohol use variables to reduce non-normality, and these log transformed variables were used in correlation and regression analyses.

Results

Twelve percent of the full sample reported consuming alcohol in the past month. Analysis of variance tests were used to examine drinking differences across grade, race/ethnicity, and gender in past month frequency, frequency of heavy drinking, quantity, and largest quantity. Results indicated differences on all drinking variables by racial/ethnic group (all p 's < .01), with Latinos reporting higher mean use. Grade differences were observed for past month frequency, quantity, and largest quantity (all p 's < .01), with older youth reporting higher levels of use. No main effects of gender were observed for these alcohol use variables.

Confirmatory factor analyses were used to test the unidimensionality of the positive and negative expectancy scales. Expectancy items were denoted as ordered categorical variables and weighted least squares was the estimation method. Results indicated that a two factor model of positive and negative expectancies fit the data well (χ^2 (53, N = 1273) = 543.45, p < .01, CFI = .95, TLI = .94, RMSEA = .09), and was superior to a one factor model of all 13 expectancy items (χ^2 (54, N = 1273) = 768.03, p < .01, CFI = .92, TLI = .91, RMSEA = .10; χ^2 difference (1, N = 1273) = 224.58, p < .001).

Differential Item Functioning

We first tested DIF for positive and negative expectancies across grade, gender, and ethnicity using the IRT likelihood ratio test. Both positive and negative expectancy items did not show DIF by grade in either location or slope parameters. For gender, positive expectancy items did not show DIF in either slope or location parameters. However for negative expectancies, one item ("aggressive") exhibited DIF in the location parameter (χ^2 (1, N = 1273) = 10.43, p < .001), indicating greater difficulty for females than for males. Likelihood ratio tests did not indicate DIF across ethnicity in slope or location parameters for positive expectancies. For negative expectancies, one item ("clumsy") showed DIF in location (χ^2 (2, N = 1273) = 7.96, p < .01). Contrast tests indicated that this item was less difficult for Caucasians than for Latinos.

For the two items demonstrating DIF in the IRT likelihood ratio test, we then used MIMIC model analyses to both provide a second indication of DIF, as well as to test whether either drinking behavior or school differences better explained DIF than ethnicity/gender. For the negative expectancy item "aggressive", gender was strongly associated with the item (Z = 3.84, p < .01), while alcohol use frequency was not (Z = .71, ns). Similarly, separate analyses indicated that gender was strongly associated with the item (Z = 5.57, p < .01), while a dichotomous school variable (intervention vs. control) was not (Z = 1.27, ns). For the item "clumsy", a dummy coded ethnicity variable (Caucasian/Latino) was strongly associated with the item controlling for either alcohol use frequency (Z = 3.11, p < .01) or school (Z = 4.42, p < .01), while alcohol use frequency (Z = .66, ns) and school (Z = 1.59, ns) were not. Additional analyses using other alcohol use variables (quantity, heavy drinking, largest quantity) indicated that none of the alcohol use variables had a direct effect on these items.

Slope and location parameters for expectancy items are presented in Table 1. Latent variable scores (theta estimates) were then obtained for each participant for positive and negative expectancy scales. For negative expectancies, scores were estimated both with and without the items demonstrating DIF ("aggressive", "clumsy"). Consistent with prior studies (Leigh & Stacy, 2004), positive and negative expectancy scores were positively correlated (r = .50, p < .01).

Associations with Drinking Behavior

We first tested cross-sectional associations between scale scores for positive and negative expectancies and drinking behaviors (Table 2). Results indicated that both positive and

negative expectancies had small but significant bivariate associations with all four drinking indicators. However, when both positive and negative expectancies are simultaneously included in a regression equation, parameter estimates for all drinking dependent variables are considerably higher. Table 2 also shows results for negative expectancies when theta is estimated including the two items demonstrating DIF (in parentheses). Results indicate that, despite the increase in scale size from adding these two questions, the inclusion of these items actually leads to a slight (non-significant) decrease in the association between expectancies and drinking.

We then examined the association between expectancies latent trait scores estimated at time 1 and drinking behaviors at time 2 (Table 3). Participants with matched data at both time points were included in these analyses ($n = 892$). For each regression analysis, time 1 drinking and school were entered at step 1, and both positive and negative expectancies were added at time 2. Results indicated that time 1 positive expectancies uniquely predicted drinking quantity, frequency of heavy drinking and largest quantity at time 2. Positive expectancies did not uniquely predict time 2 drinking frequency. Negative expectancies were not uniquely associated with any time 2 drinking behaviors.

Discussion

In this study, we used an IRT framework to examine the psychometric performance of positive and negative expectancy items of the B-CEOA in middle school youth. Results indicated that positive expectancy items did not exhibit DIF across grade, gender, and ethnicity. Two negative expectancy items did exhibit DIF, one across gender and one across racial/ethnic group. For these items, MIMIC model analyses indicated that drinking differences did not explain differences in item parameters. Removal of these items did not significantly affect prediction of drinking behavior.

Although item parameters of positive expectancies have been examined in prior studies (see Mackintosh, Earleywine, & Dunn, 2006) to our knowledge this is the first study to evaluate item parameters of both positive and negative expectancies. As is clear from Table 1, negative and positive expectancies systematically differ in location for this age group; the location parameter is positive for positive expectancies and negative for negative expectancies. This pattern of results suggest a higher difficulty for positive expectancies in middle school youth, meaning that higher levels of the latent trait are needed for youth to endorse agreement with positive expectancy items than negative expectancy items. Although we examined positive and negative expectancies as separate latent traits, supplementary analyses (not reported) indicated that this pattern was replicated when they are estimated as part of a single latent trait. This is consistent with prior studies indicating that young children exhibit greater negative than positive alcohol expectancies (Johnson & Johnson, 1995), and adds to this literature by demonstrating that this difference is reflected in item difficulty.

Results also suggest that both positive and negative expectancy scales assess relatively narrow ranges of item difficulty. This may be due to the fact that the CEOA was constructed using principles of classic psychometric theory, which emphasizes item overlap to maximize internal consistency. One direction for future research would be to refine measures of alcohol expectancies to provide information over a broader range of the latent trait. Doing so may have important implications for alcohol intervention research, as it could improve our ability to identify those with very high positive or very low negative alcohol expectancies, who may be at particular risk for problematic alcohol involvement.

Two negative expectancy items exhibited DIF across groups in the location parameter. The item "I would act aggressively" exhibited DIF across gender, while the item "I would feel

clumsy” exhibited DIF across ethnic group. This means that the IRT assumption of conditional independence does not hold for these items – the difficulty of these items is determined not only by the underlying trait, but differs as a function of group status. MIMIC model results indicate that DIF was not due to alcohol involvement or the school-based intervention. For the “aggressive” item, it is likely that gender differences in aggression (Anderson & Bushman, 2002) explain part of the difference in item functioning between boys and girls. However, further research would be required to understand whether this fully accounts for the gender DIF on this item, and to test potential explanations for ethnic differences in the “clumsy” item. Methods for testing DIF as a function of latent classes (Cohen & Bolt, 2005), rather than manifest grouping variables, may provide a better understanding of the root cause of DIF in expectancy items.

Cross-sectional associations of positive and negative expectancy scales with drinking demonstrated evidence of suppression. One explanation for this effect is that including both positive and negative expectancies in the same equation partials out common variance between them that is likely unrelated to alcohol use behavior (Leigh & Stacy, 2004). As Leigh and Stacy (2004) note, the repeated finding of suppression emphasizes the importance of including both positive and negative expectancies in the same model.

One limitation of the present study is the significant differences between our matched and unmatched sample. To protect confidentiality, a matching procedure was used to link time 1 and time 2 data for prospective analyses. Matching participants on immutable characteristics leads to loss of data due to duplicate identifiers and failure to match unique identifiers, on top of normal attrition that would be expected in a prospective study. The match rate we obtained is comparable to other studies that have used this technique (D’Amico & McCarthy, 2006; Stice et al., 1998). Similar to prior studies, matched and unmatched participants differed in their demographic characteristics and use of alcohol, which may limit the generalizability of prospective analyses. However, this did not influence the majority of study analyses, including item parameter estimation and tests of DIF, which were conducted on the full sample.

An additional limitation to the generalizability of the study is that the study was conducted in two middle schools, one of which received an alcohol intervention during the period of the study (see D’Amico & Edelen, 2007). Approximately 13% of students in this school participated in this intervention. However, as no identifying information was collected as part of the survey, it was not possible to directly test potential effects of this intervention on expectancies or to exclude intervention students from study analyses. School was controlled for in regression analyses, and significant associations for school indicated greater drinking in the control school. MIMIC model analyses also indicated that DIF results did not differ by school.

Results of this study demonstrate the utility of IRT analyses of positive and negative expectancy scales. Further research is required to test potential developmental differences in expectancy item parameters across longer time periods. Results of this study also suggest the potential importance of refining existing expectancy scales to cover a broader range of the latent trait, which can improve the ability of these scales to identify youth at-risk for heavy alcohol involvement.

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Expectancy Item Parameters**Table 1**

Variable	Slope	Location
Positive		
Feel peaceful	1.25 (.059)	.89 (.046)
Be brave and daring	1.53 (.074)	.43 (.040)
Be courageous	1.72 (.094)	.58 (.039)
Feel calm	1.19 (.053)	.75 (.046)
Be easier to talk to people	1.16 (.055)	.70 (.044)
Act sociable	1.16 (.045)	.50 (.045)
Total	1.34 (.236)	.64 (.170)
Negative		
Feel dizzy	1.61 (.075)	-.40 (.038)
Be loud, boisterous, or noisy	1.46 (.069)	-.12 (.038)
Feel guilty	.98 (.038)	.05 (.046)
Feel moody	1.67 (.079)	-.03 (.037)
Take risks	1.18 (.049)	-.05 (.042)
Total	1.38 (.295)	-.11 (.172)

Note. Values are item parameters and standard errors (in parentheses). Item parameters for items demonstrating DIF are not presented.

Table 2
Correlation and Regression Analyses of Theta Estimates of Positive and Negative Expectancies Predicting Alcohol Use

	Frequency	Quantity	Heavy Drinking Freq.	Largest Quantity
Bivariate Correlations				
Positive expectancies	.09	.10	.08	.10
Negative expectancies	-.08 (-.07)	-.11 (-.10)	-.09 (-.08)	-.10 (-.10)
Regression Analyses				
Positive expectancies	.19 (.17)	.21 (.20)	.16 (.16)	.21 (.20)
Negative expectancies	-.18 (-.16)	-.22 (-.20)	-.17 (-.16)	-.21 (-.20)

Note. $N = 1273$. Values are correlation coefficients or standardized regression coefficients. Values in parentheses are from scale score estimates including items with DIF. All correlations are significant at $p < .01$.

Table 3

Regression Analyses of Latent Variable Scores of Positive and Negative Expectancies (Time 1) Predicting Time 2 Alcohol Use.

	Frequency	Quantity	Heavy Drinking Frequency	Largest Quantity
Step 1				
Time 1 Use	.22 *	.22 *	.25 *	.20 *
School	.15 *	.15 *	.10 *	.13 *
R ²	.07	.07	.08	.06
Step 2				
Positive	.07	.14 *	.13 *	.13 *
Negative	.02	-.03	-.02	-.02
R ²	.08	.09	.09	.08

Note: $n = 892$. Values are standardized regression coefficients or R^2 values. School is a dichotomous variable (intervention school = 0, control school = 1).

* $p < .01$.