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Differential item functioning analysis of the CUDIT and relations with alcohol and tobacco use among men across five ethnic groups: the HELIUS study

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Abstract

Cannabis use has been rising, despite recognition of the negative consequences associated with heavy use. The severity of these consequences has been shown to differ across racial/ethnic groups, even when controlling for consumption levels. The present study conducted an item response theory (IRT) analysis of the Cannabis Use Disorders Identification Test (CUDIT) to better understand the patterns of problematic cannabis use and their relation with other substance use across ethnic groups in the HELIUS study. CUDIT responses from 1,960 cannabis using African Surinamese, South-Asian Surinamese, Dutch, Moroccan, and Turkish ethnic origin participants were used to test for differential item function (DIF) within an IRT framework. Restricting the sample to men due to low frequency of use among women, several instances of uniform DIF were identified. Multiple group IRT analysis yielded a harmonized cannabis use phenotype that was used to estimate ethnic group differences in problematic cannabis use and its relation to alcohol and tobacco co-use. These analyses suggested that cannabis users from certain ethnic minority groups experienced higher rates of problematic use than the majority group despite lower rates of cannabis use. Further, cannabis and tobacco use were positively related across

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groups, whereas only ethnic minority groups showed a positive relation between cannabis and alcohol use. These results demonstrate the importance of accounting for DIF when examining group differences in problematic cannabis use, and support prior evidence suggesting that certain ethnic minority groups may be more likely to experience problematic cannabis use and alcohol co-use relative to the majority group.

Keywords

cannabis; alcohol; tobacco; cross-cultural; item response theory

Attitudes regarding cannabis have shifted dramatically in the past several decades, leading to significant increases in the prevalence of cannabis use, despite growing recognition of the negative consequences associated with heavy use (Volkow, Baler, Compton, & Weiss, 2014). Among these consequences are higher rates of alcohol and tobacco use (Khan et al., 2013), and while there are significant physical and mental health risks associated with the heavy use of each individual substance (Gowing et al., 2015; Hall & Degenhardt, 2009), their combined use results in further increases in associated health risks (Jane-Llopis, Jané-Llopis, & Matytsina, 2006; Ramo, Liu, & Prochaska, 2012). For example, co-use of alcohol, nicotine, and cannabis is associated with higher rates of negative consequences associated with substance use (e.g., impaired driving, risky sexual behavior, violence) (Peters, Schwartz, Wang, O'Grady, & Blanco, 2014; Meenakshi S Subbaraman & Kerr, 2015), higher rates of emergency department admissions (John & Wu, 2017), higher rates of substance use disorders (Regier et al., 1990), higher rates of comorbid psychiatric conditions (Agosti, Nunes, & Levin, 2002; Peters, et al., 2014), and poorer treatment outcomes for both substance use and other psychiatric disorders (Meenakshi Sabina Subbaraman, Metrik, Patterson, & Swift, 2017; Weinberger, Platt, & Goodwin, 2016).

Importantly, the rate and severity of these consequences have been shown to differ as a function of racial/ethnic group membership, even when controlling for consumption levels (Witbrodt, Mulia, Zemore, & Kerr, 2014; Zapolski, Pedersen, McCarthy, & Smith, 2014). In terms of prevalence rates, longitudinal studies conducted in the United States have shown that among adolescent groups, non-Hispanic Whites tend to show higher rates of alcohol, tobacco, and cannabis use relative to Black and Hispanic youth, though these racial and ethnic differences tend to decline and, for some substances, disappear in adulthood (Chen & Jacobson, 2012; Keyes et al., 2015). Despite lower rates of use in adolescence and early adulthood, several studies suggest that these racial and ethnic minority groups experience greater negative consequences associated with substance use, higher rates of disordered use, and lower rates of treatment access and completion (Chartier & Caetano, 2010; Wells, Klap, Koike, & Sherbourne, 2001; Wu, Zhu, & Swartz, 2016). Thus, a better understanding of the patterns of use and co-use of these substances across diverse populations has the potential to improve prevention and intervention efforts seeking to reduce the rates of substance use disorders and reduce the significant societal costs associated with these disorders.

Given that ethnicity is often related to other variables, such as socioeconomic status (SES), particularly when looking at recent immigrant populations (Singh & Siahpush, 2002), it can

be difficult to determine to what extent ethnic differences in prevalence rates of a given condition result from meaningful cultural and contextual differences, including those associated with minority status such as experiences of discrimination (Shavers, 2007; Williams, 1996). A further complication of studying this issue is the use of self-report questionnaires that, despite careful translation across languages, may be interpreted differently by individuals belonging to distinct cultural groups (Gregorich, 2006).

Item response theory (IRT) approaches allow for the exploration of differences in symptom functioning across populations, including those stratified by gender or ethnicity (Hui & Triandis, 1985). IRT models are based on the assumption that a continuous latent dimension underlies a trait of interest and that the individual items contained within a measure serve as indicators of where an individual lies along this dimension. Specifically, the location of each item on this latent dimension is defined by the point at which the item has a 50% probability of endorsement by someone at that level of the trait (Embretson & Reise, 2000). Thus, these estimates provide measures of item difficulty that are related to the endorsement rate of the item with high frequency items considered to be low difficulty and low frequency items considered to be high difficulty items. Additionally, how precisely the item can be located on the latent trait provides an index of item discrimination. For example, IRT methods have been widely applied to measures of substance use and substance use disorders and were used to demonstrate that the DSM-IV substance abuse and dependence symptoms, rather than indexing distinct, hierarchical disorders, measured a single construct (O'Brien, 2011).

Importantly, IRT models can also be used to test whether these difficulty and discrimination parameters differ across groups such as ethnicity and gender, differences typically referred to as differential item functioning (DIF) (Thissen, Steinberg, & Wainer, 1993). Presence of DIF results from differences in the endorsement rates of an individual item relative to the other items of the measure. The first aim of this study was to conduct an IRT analysis of the Cannabis Use Disorders Identification Test (CUDIT) (Adamson & Sellman, 2003) to identify and account for instances of DIF across ethnic groups living in Amsterdam, the Netherlands. Previously, the IRT approach was successfully applied to DIF of the Fagerstrom Test of Nicotine Dependence Scores in the present sample (van Amsterdam et al., 2019). Nonetheless, no specific predictions regarding the nature of anticipated DIF were made. The second aim was to identify differences in cannabis use severity across these ethnic groups. Based on the reviewed literature, we expected that members of the minority groups that reported using cannabis would report higher rates of negative consequences resulting from their use. The third aim was to use results from the IRT analysis to test for differences in the severity of cannabis use and alcohol and tobacco co-use across these ethnic groups.

Method

Study population

The current study utilized participant baseline data from the HELIUS (HEalthy Life in an Urban Setting) study. This is a large population-based, prospective cohort study conducted in Amsterdam, the Netherlands. The main objective of this study is to evaluate the causes of disease across ethnic groups, mainly focusing on cardiovascular, mental and infectious

diseases. The study has been described in detail elsewhere (Snijder et al., 2017; Stronks et al., 2013). Briefly, HELIUS is a multi-ethnic cohort study of participants recruited from the Amsterdam Municipality Register, The Netherlands. Baseline data collection took place in 2011-2015. A total of 23,942 participants, completed the HELIUS questionnaire, which included the Cannabis Use Disorders Identification Test (CUDIT). The HELIUS protocol was approved by the Ethical Review Board of the Academic Medical Center Amsterdam. All participants gave their written informed consent.

For the current study, we excluded those of Javanese Surinamese (n=250) or other/unknown Surinamese (n=286) origin due to small numbers of cannabis users in these groups (n=31 and 1, respectively), and we excluded those with another/unknown ethnic origin (n=50). Among the remaining 23,356 participants, Dutch origin participants showed the highest percentage of lifetime cannabis use (48.2% lifetime abstainers), followed by African Surinamese (67.7% lifetime abstainers), South-Asian Surinamese (78.7% lifetime abstainers), Moroccan (86.0% lifetime abstainers), and Turkish origin participants with the lowest percentage of lifetime cannabis use (86.4% lifetime abstainers). CUDIT data for item response theory (IRT) differential item function (DIF) analyses were available for 2,024 participants (70.4% male) after excluding participants who had never used cannabis (17,354 individuals), had not used cannabis in the past 6 months (3,805 individuals), had not completed the CUDIT (148 individuals) or had missing data for more than one CUDIT item (25 individuals). Sixty-four Ghanaian origin (Table 1) participants were additionally excluded due to the small sample size and sparse endorsement of several CUDIT items. Therefore, IRT DIF tests were conducted for 1,960 individuals representing the five largest ethnicity groups: Dutch (n=576), African Surinamese (n=653), South-Asian Surinamese (n=312), Moroccan (n=213) and Turkish (n=206) origin.

Measures

Ethnicity.—Participants' ethnicity was defined according to the country of birth of the participant as well as that of the parents (Stronks, Kulu-Glasgow, & Agyemang, 2009). More specifically, a person was defined as of non-Dutch ethnic origin if he/she fulfilled one of two criteria: (1) he/she was born outside the Netherlands and had at least one parent born outside the Netherlands (first generation) or (2) he/she was born in the Netherlands but both parents were born outside the Netherlands (second generation). For the Dutch origin sample, we invited people who were born in the Netherlands and whose parents were born in the Netherlands. After data collection, participants of Surinamese ethnic origin were further classified according to self-reported ethnic origin (obtained by questionnaire) into 'African Surinamese', 'South-Asian Surinamese', 'Javanese Surinamese' or 'other/unknown Surinamese'.

Cannabis Use.—The Dutch version of the CUDIT (Adamson & Sellman, 2003) was included in the HELIUS questionnaire to measure cannabis use severity. The CUDIT is based on the Alcohol Use Disorders Identification Test (AUDIT), using identical item ratings and similar interpretation of sum scores (range 0-40) (Babor, Higgins-Biddle, Saunders, & Monteiro, 2001). It contains 10 items assessing cannabis use in the past six months assessing frequency of use and symptom frequency. Eight of these items have five

response categories and the other two are dichotomous 'yes/no' questions. Prior studies have demonstrated the CUDIT to have acceptable internal consistency (Cronbach's α=0.84) and one-week test-retest reliability (r=0.85) (Adamson & Sellman, 2003; Adamson et al., 2010), and have shown strong correspondence with DSM-IV cannabis dependence diagnostic status (positive predictive power = 85%, negative predictive power = 90%) (Adamson & Sellman, 2003).

In the present study, if one of the 10 items was missing, the CUDIT sum score was calculated without that item. If more than 1 item was missing, the CUDIT sum score was not calculated and coded as missing. As noted above, this resulted in the exclusion of data from 25 (20 male) participants. Internal consistency was acceptable when assessed in the full sample (Cronbach's α=0.84) and within each of the ethnic groups (Cronbach's α>0.80 for each group). A set of preliminary regression analyses using CUDIT sum scores (range 1 – 40 among cannabis users) were conducted as a baseline against which IRT-derived latent variable scores were evaluated. Though we opted to analyze the sum scores rather than create binary diagnostic categories, prior studies have suggested an optimal cutoff score of ≥ 8 for identifying individuals with current cannabis use disorder (Adamson & Sellman, 2003; Annaheim, Rehm, & Gmel, 2008; Thake & Davis, 2011).

Alcohol Use.—Alcohol use was assessed using the AUDIT (Babor, et al., 2001; Saunders, Aasland, Babor, De la Fuente, & Grant, 1993). For the current study, the first three items comprising the AUDIT-Consumption index (AUDIT-C) (Bush, Kivlahan, McDonell, Fihn, & Bradley, 1998) were scored (sum score range 1 to 12) as a measure of consumption.

Tobacco use.—To assess tobacco use, participants completed the six-item Fagerström Test for Nicotine Dependence (FTND) (Heatherton, Kozlowski, Frecker, & Fagerström, 1991). Responses to the first FTND item ("Do you smoke at all?"; 1 "No, I have never smoked", 2 "No, but I used to smoke" and 3 "Yes") were ordered to generate an ordinal three-level 'smoking status' variable with the following categories: non-smoker, former smoker, and current smoker. Additionally, FTND sum scores (range 0-10) were calculated as a measure of tobacco use severity.

Socioeconomic status.—Socioeconomic status was assessed in the current study using participant educational level. Four categories were used to classify highest level of education attained (either in the Netherlands or in the country of origin): 1 low ("never been to school or elementary schooling only,") 2 medium-low ("lower vocational schooling or lower secondary schooling"), 3 medium-high ("intermediate vocational school or immediate/ higher secondary schooling"), and 4 high ("higher vocational schooling or university").

Data Analysis

IRT analysis.—In the current study, likelihood-ratio tests comparing IRT models were used to test for invariance of item response parameters across ethnicity and gender (Thissen, et al., 1993). A significant result indicates the probable presence of DIF, suggesting that a particular item artificially presents one group as being higher or lower than others on the latent trait of interest as a consequence of group membership rather than actual differences

in trait characteristics. For the ethnicity-based DIF tests, the Dutch group was designated as the reference group and simultaneously tested against the ethnic focal groups. For the gender-based DIF tests, men were specified as the reference group and women constituted the focal group. As described in detail below, the gender-based analyses suggested the presence of DIF, and due to the relatively small number of cannabis using women, further analyses were restricted to men. Sample sizes for subsequent analyses were thus reduced: Dutch (n=344), African Surinamese (n=453), South-Asian Surinamese (n=251), Moroccan (n=175), and Turkish (n=157) origin.

Given the polytomous nature of the CUDIT items, DIF analyses were conducted using two-parameter graded response IRT models (Samejima, 1969). Accordingly, only the slope (a; discrimination) and threshold (b; difficulty) parameters were estimated in the present analyses. An omnibus test of DIF was initially conducted by comparing the fit of a baseline model in which the a and b parameters were allowed to vary across groups to that of a more constrained model in which these parameters were fixed across groups. A Bonferroni-corrected alpha level of $p<0.008$ was used to account for the 6 items that were tested. More specific tests were then conducted constraining each parameter individually in turn and comparing the fit to the baseline model without correction. All IRT analyses were conducted using the R package ‘mirt,’ whose full information maximum likelihood method can handle individuals with some missing items (Chalmers, 2012; R Core Team, 2016). Prior to conducting the IRT-based DIF analyses, anchor items assumed to be invariant across groups were statistically selected (Thissen, et al., 1993). The optimal number of anchor items to specify for a given test of DIF were determined based on the sample sizes of the groups being compared, the magnitude of expected DIF, and the number of items included in the CUDIT. Given guidelines suggested by prior simulation studies (Lopez Rivas, Stark, & Chernyshenko, 2009; Woods, 2009), three items were identified for the ethnicity DIF tests and two for the gender DIF tests.

Two approaches to anchor item selection were used. The first approach used a two-stage procedure. In the first stage, a free baseline model was specified in which item parameters (difficulty and discrimination) were allowed to vary freely across groups, and an initial anchor item was selected based on having the largest estimated discrimination value. A model including this initial anchor item then served as a baseline against which subsequent items, beginning with the item with the next highest discrimination value, could be evaluated in turn by constraining the parameters of that item to be equal across groups and examining changes in model fit compared to the baseline (Lopez Rivas, et al., 2009). Provided the constraint of an item did not result in worse model fit, this item was retained as an anchor and subsequent fit comparisons were made with regard to this more parsimonious baseline model. This process was then repeated until no additional anchor items could be identified (i.e., constraining any additional items led to a significant chi-square difference test indicated by a p-value < 0.05) or the desired number of anchor items, as discussed above, were identified. The second approach, an all-others-as-anchors (AOAA) approach, began with a fully constrained model where are all items were constrained to be equal across groups. The parameters of each item in turn were then freed allowing the other items to serve as anchor items, and the resulting model was compared to the fully constrained model. The items yielding the smallest likelihood ratio statistic divided by the number of free

parameters were chosen to function as anchor items (Lopez Rivas, et al., 2009; Meade & Wright, 2012). Items that showed evidence of invariance across both approaches were ultimately selected as anchors.

DIF analyses were then conducted using CUDIT items 1-8, and 10. Item 9 ("Have you or someone else been injured as a result of your use of cannabis over the past 6 months?") was excluded due to very low endorsement rates across all groups (0.56%). One benefit of IRT-based DIF analyses over other statistical approaches is the ability to examine whether the observed DIF is uniform or non-uniform across the trait of interest. Uniform DIF refers to group bias being continuous across levels of the latent trait spectrum (θ; significant group differences in item difficulty), whereas non-uniform DIF suggests that the bias may be present at certain levels of the trait resulting from significant group differences in item discrimination. Following the ethnicity-based multiple group DIF tests, separate pairwise DIF tests were conducted comparing item-level and parameter-level functioning for Dutch origin participants (reference group) to each minority group. Because effect size estimates of observed DIF on CUDIT scores could not be readily estimated from the full multiple group model, effect size estimates were obtained from these pairwise analyses. Three methods quantifying the expected score difference between groups resulting from DIF were then used to estimate the magnitude of DIF. The unsigned test difference in the sample (UTDS) indicates the absolute values of deviations attributable to DIF across items, whereas the signed item and test differences in the sample (SIDS and STDS, respectively) preserve the positive and negative score deviations attributable to DIF at the item and measure level, respectively (Meade, 2010).

Regression analyses examining patterns of cannabis and other substance use.—Following IRT analyses, θ values were obtained for each participant from a final multiple group IRT model that allowed the parameters of all items not designated as invariant anchors to be freely estimated across groups, thus accounting for possible DIF. Preliminary regression analyses were conducted using linear regression models comparing the ability of self-reported ethnicity variables to predict CUDIT sum scores and the IRT-derived θ values. Based on the results from these analyses, the IRT-derived θ values were then used to examine the relations between cannabis use and alcohol consumption and tobacco use and the moderation of these relations by ethnicity and socioeconomic status. The first models specified CUDIT θ values as the independent variable and the substance use outcome of interest (i.e., alcohol consumption, smoking status, FTND score) as the dependent variable. Subsequent models included a set of dummy-coded variables indicating ethnic group membership and a variable indicating education level, as well as their interactions with the CUDIT θ values, as additional independent variables. Mean-centered age at time of questionnaire completion was used as a covariate in all analyses. Variance explained estimates (R^2 or Nagelkerke R^2) served as effect size indices with 95% confidence intervals (CIs) around these estimates calculated using a bootstrapping approach (Efron & Tibshirani, 1994).

Results

IRT Analyses

Initial analyses conducted on the full sample using both the two-stage and AOAA approaches identified items 4 (“How often during the past six months did you find that you were not able to stop using cannabis once you had started?”), 6 (“How often during the past 6 months did you need to use cannabis in the morning to get yourself going after a heavy session of using cannabis?”), and 10 (“In the past 6 months, has a relative, friend or a doctor or other health worker been worried about your cannabis use or suggested you cut down?”) as the most appropriate anchor items. We then conducted tests of DIF across ethnic groups. As shown in Table 2a, no evidence of nonuniform DIF was detected as indicated by the nonsignificant discrimination (*a*) parameters; however, several items showed evidence of uniform DIF as indicated by the significant difficulty (*b*) parameters.

A primary aim of the present study was to examine patterns of DIF across ethnic groups as a means for conducting cross-ethnic group analyses of cannabis and other substance use patterns; however, the small number of cannabis using women (n=580) and sparse endorsement of several items did not allow for ethnicity-based DIF tests to be conducted separately for men and women. As a result, we conducted a set of DIF analyses across gender to determine the appropriateness of combining men and women into a single sample. Items 3 (“Last six months, how often were you stoned for 6 hours or longer?”) and 6 were identified as the most appropriate anchor items, and while no evidence of nonuniform DIF emerged, several items showed evidence of uniform DIF (see Table 3). These results suggested that combining men and women into a single sample could bias study results, and thus, we decided to restrict all subsequent analyses to men.

Accordingly, further tests of model fit and tests of DIF across ethnic groups were run using only data from men. A confirmatory factor analysis conducted using data from the full sample of men suggested a single-factor model was appropriate ($M_2^* = 45.5$, RMSEA=0.09 [90% CI=0.07-0.11]; SRMSR=0.08, TLI=0.89, CFI=0.97). Further analyses conducted separately for each ethnic group suggested continued evidence for unidimensionality, though this evidence was certainly weaker for some groups relative to others, suggesting the possibility of nonuniform DIF (see Supplementary Table 1). Tests of item monotonicity were conducted, which suggested minimal deviations from expectations in item-level fit when the sample was analyzed as a whole (Supplementary Table 2) and when each ethnic group was analyzed separately (Supplementary Table 3).

Based on these analyses, we proceeded to test for DIF in the subsample of men using a single-factor IRT model. As shown in Table 2b, the observed evidence for DIF was reduced when the sample was restricted to men, but some degree of DIF was still present as suggested by the item-level omnibus tests, with Items 1, 2, 7, and 8 showing significant evidence of DIF and Items 3 and 5 showed nominally significant evidence of DIF. Further, Item 1 continued to show evidence of DIF at each threshold of the item (i.e., 1 to 2, 2 to 3, etc.).

As described, follow up pairwise DIF analyses were then conducted comparing each minority ethnic focal group to the Dutch origin reference group. Results from these pairwise comparisons indicated the presence of at least nominally significant item-level DIF for Item 7 across each group and at least nominally significant item-level DIF for Item 1 for all but the Moroccan group (see Supplementary Table 5 for results). Using the signed item difference in the sample (SIDS), which is an effect size measure indicating the expected score difference between groups resulting from DIF, Item 1 showed a positive effect for African and South-Asian Surinamese participants relative to the Dutch participants (.29 and .21, respectively) and a negative effect for the Moroccan and Turkish participant relative to the Dutch participants (−.11 and −.23, respectively). This indicates that the African and South-Asian Surinamese participants reported greater cannabis use than Dutch participants at a given level of the underlying liability scale (θ), whereas the Moroccan and Turkish participants reported less cannabis use than Dutch participants at a given level of θ (see Supplementary Figure 1). To further illustrate this result, we recalculated the CUDIT sum scores by removing Item 1 from the sum and then used box and whisker plots to display the distributions of these recalculated CUDIT scores as a function of Item 1 response for each ethnic group (see Figure 1). As can be seen most clearly for participants that endorsed using cannabis “2-3 times a week” or “4 or more times a week,” the African and South-Asian Surinamese participants exhibited a lower recalculated CUDIT sum score, whereas the Moroccan and Turkish participants exhibited a higher recalculated CUDIT sum score, relative to the Dutch participants.

To further assess the potential impact of observed DIF across items on CUDIT scores, additional effect size estimates were obtained at both the item- and scale-level. At the item level, the SIDS showed the largest effects for item 7, with values ranging from −0.21-0.42 (raw scores of this item ranged from 1-5) (see Supplementary Figure 2). The unsigned test difference in the sample (UTDS), which sums the absolute values of the expected score differences in the sample for each item thus creating an overall measure-based index of DIF, ranged from a high of 1.22 points for the African Surinamese to a low of 0.71 for the Turkish relative to Dutch participants. The signed test difference in the sample (STDS), which preserves the positive and negative score differences when summing across items thus allowing positive and negative instances of DIF across items to balance out, ranged from a deviation of −0.46 for the African Surinamese relative to Dutch participants to a deviation of −0.18 for the South-Asian Surinamese relative to the Dutch participants. For a complete report of effect size estimates see Supplementary Table 5. To provide some context for these effect sizes, group mean differences on the CUDIT as presented in Table 1 ranged from 3.2 to 6.4.

Regression analyses examining patterns of cannabis and other substance use

Relations between ethnic group membership and cannabis use.—We conducted an initial test of the potential impact of uncorrected DIF when estimating group differences by comparing the explanatory power of ethnic group membership when predicting CUDIT sum scores relative to the IRT θ values in two separate regression models. Because of concern regarding the conservative nature of Bonferroni corrections, θ values were derived from a multiple group model in which parameters for all items showing nominally

significant evidence of DIF were allowed to vary (see Supplementary Table 6 for parameter estimates). Notably, these θ values correlated 0.99 with those derived from a model in which only parameters corresponding to items displaying statistically significant levels of DIF were allowed to vary. The described regression models indicated stronger associations between self-reported ethnicity and IRT θ values compared to the raw CUDIT sum scores, with the R^2 value of the former model almost triple that of the latter model (R^2=0.21, 95% CI 0.17-0.25 vs. R^2=0.08, 95% CI 0.05-0.10), suggesting the θ values capture important differences across these ethnic groups in a manner that CUDIT sum scores could not. Thus, subsequent analyses relied on the θ values as an index of problematic cannabis use. These analyses showed that, among male cannabis users, the non-Dutch origin participants scored significantly higher on the CUDIT relative to the Dutch participants even after controlling for educational level (African - b=0.79, SE=0.08, t=9.44, p<0.001, South Asian - b=0.83, SE=0.07, t=11.36, p<0.001, Turkish - b=0.83, SE=0.10, t=8.63, p<0.001, Moroccan - b=1.35, SE=0.09, t=14.51, p<0.001).

Relations between cannabis and alcohol use.—A model examining the relations between the CUDIT θ values, ethnic group membership, and educational level with alcohol consumption as measured by the AUDIT-C was then specified. The full model, which included interactions between all predictors, did not reveal significant interaction effects with educational level. For ease of presentation, the results of a reduced model including the main effects of all variables and the interaction effects between the ethnicity variables and the CETDIT θ values are shown in Table 5. As noted, the main effects of ethnic group membership were qualified by significant interactions with the CUDIT θ values. The overall interaction is displayed in Figure 2 where a positive relation between CUDIT θ values and AUDIT-C scores can be seen for each of the ethnic groups, whereas a slight negative relation is observed among the Dutch participants.

Relations between cannabis and tobacco use.—Similar to the analyses of the AUDIT-C, analyses investigating the relation between CUDIT θ values and smoking status (i.e., never, former, current) and CUDIT θ values and FTND scores were first conducted using a full model that included interaction terms between all predictors. None of the interaction terms yielded a significant result, and thus, were dropped from both models. As shown in Table 5a, there was a significant main effect of CUDIT θ values on smoking status as well as main effects of African Surinamese, South-Asian Surinamese, and Turkish (relative to Dutch) ethnic group membership and educational level on smoking status. Similar results emerged for the relations with FTND scores, though the main effect of Moroccan (relative to Dutch) ethnic group membership was significant and the main effect of South-Asian Surinamese (relative to Dutch) ethnic group membership was non-significant (Table 5b). Educational level was also significantly related to FTND scores. The relative similarity in the relations between CUDIT θ values and smoking status and FTND scores as a function of ethnic group membership are displayed in Figures 3a and 3b, respectively.

Discussion

The primary aim of the present study was to better understand the patterns of cannabis use severity and its relations with other substance use across ethnic groups in the HELIUS study.

To accomplish this, an initial graded response IRT analysis was conducted to identify evidence of DIF for items contained in the CUDIT as a function of ethnic group membership. The results of this analysis were then used to create a harmonized cannabis use phenotype (CUDIT θ values) that could be used to compare cannabis use severity and its relations with alcohol and tobacco use across the studied ethnic groups. We first discuss the implications of the IRT and DIF analyses before discussing the substantive findings regarding differences in cannabis use across ethnic groups and the implications of the study findings for the assessment of cannabis use in different ethnic groups. As described, the primary analyses were restricted to men due to the low rates of cannabis use among women. After restricting the sample in this manner, some degree of DIF was observed for all items as suggested by the item-level omnibus tests. The largest effect size was observed for item 7, 'How often during the past 6 months did you have a feeling of guilt or remorse after using cannabis?,' though none of the individual parameters was significant. Specifically, African and South-Asian Surinamese participants scored lower than would be expected and Moroccan and Turkish participants scored higher than expected on this item relative to Dutch origin participants assuming an equal value on the underlying liability scale. Only item 1 showed significant evidence of DIF between response categories. Item 1 asks individuals 'how often do you use cannabis?', which when restricted to current cannabis users has the following response options, 'monthly or less,' '2-4 times per month,' '2-3 times a week,' and '4 or more times a week.' For this item, African and South-Asian participants scored higher than would be expected and Moroccan and Turkish participants scored lower than would be expected on this item relative to Dutch origin participants assuming an equal value on the underlying liability scale.

These results suggest two possible sources contributing to DIF of the CUDIT items. First, differences in interpretation or cultural attitudes could be responsible for some of the observed DIF given that acceptance of cannabis use, and thus the potential for experiencing guilt and/or remorse following cannabis use, might vary as a function of culture. Second, the presence of DIF for item 1 suggests that ethnic groups might also differ in the relations between the frequency of cannabis used and the rate at which they experience or exhibit the other behaviors assessed by the CUDIT. Whether these differences reflect differences in vulnerability to the consequences of heavy cannabis use or reflect general over- or under-reporting of symptoms across groups will require further study. It should also be noted that the evidence for unidimensionality of the CUDIT was weaker for some ethnic groups (i.e., Dutch and Moroccan) relative to others (e.g., Turkish). Though there was not significant evidence for nonuniform DIF, it is possible that some of the observed DIF at the omnibus level could have resulted from differences in the factor structure of the CUDIT across ethnic groups. In either case, these results suggest that researchers should be sensitive to potential measurement issues when administering the CUDIT to diverse samples, and also highlight the need to replicate these findings in larger samples.

With respect to the substantive findings regarding differences in cannabis use across ethnic groups, the present analyses revealed that although a higher percentage of Dutch participants report using cannabis overall, participants from ethnic minority groups that report cannabis use endorse higher levels of problematic use as indicated by higher CUDIT θ values relative to Dutch cannabis users, consistent with our predictions. Previous studies have noted similar

results suggesting that members of many ethnic minority groups will report less overall use of a given substance, but report higher rates of negative consequences, including addiction, relative to members of the majority group (Chartier & Caetano, 2010; Wu, et al., 2016). Notably, prior studies have been conducted primarily using samples drawn from the United States and have focused on differences between the predominant racial and ethnic groups there (i.e., European-American, African-American, Hispanic, Asian) (Chen & Jacobson, 2012; Keyes, et al., 2015; Wu, et al., 2016). Thus, the current results provide evidence extending these findings to European samples and ethnic groups that have not been previously studied (i.e., Turkish, Moroccan). While the present study cannot draw conclusions regarding the underlying causes, prior studies have suggested that reduced access to treatment, racial/ethnic discrimination, and residence in higher crime areas with lower access to public services can account for some of the observed disparities (Chartier & Caetano, 2010; Wells, et al., 2001; Zapolski, et al., 2014).

A second substantive finding to emerge from the present study was the difference in relations between cannabis and tobacco use vs. cannabis and alcohol use among men. Specifically, cannabis use severity was positively correlated with tobacco use across all ethnic groups on at least one of the smoking variables (i.e., smoking status or FTND scores). It is likely that the similar correlations between cannabis and tobacco use across ethnic groups is driven in large part by the shared route of administration between cannabis and tobacco (Hindocha, Freeman, Ferris, Lynskey, & Winstock, 2016). Several studies have demonstrated that both substances are frequently mixed together and smoked, and this leads to higher rates of their co-use and co-dependence (Hublet et al., 2015; Ramo, et al., 2012). In contrast, cannabis use severity was shown to be positively correlated with alcohol use among members of ethnic minority groups, but showed little relation with alcohol use among Dutch participants. The factors underlying these different patterns of cannabis and alcohol co-use across ethnic groups are not clear at this time. Nonetheless, the lack of interactions between educational level and CUDIT θ values when predicting AUDIT-C scores suggests that the different patterns of alcohol and cannabis use observed between the Dutch and ethnic minority groups were independent of differences in one measure of socioeconomic status between these groups.

Finally, it is important to comment on the implications of the findings related to DIF as well as the observed ethnic differences in cannabis use for future studies as well as prevention and intervention efforts that may rely on measures such as the CUDIT to screen for problematic substance use. As noted above, the effect sizes for the observed DIF were relatively small; however, the effect sizes for ethnic group comparisons of CUDIT were considerable (R^2 = 0.08 for raw scores vs. 0.21 for CUDIT θ values). This suggests that using DIF-adjusted scores could improve the ability to detect meaningful differences between groups as has been widely argued in the prior literature (Embretson & Reise, 2000; Thissen, et al., 1993). In assessment settings, however, when the focus is on individual diagnosis and prediction, it is less clear to what extent adjusting for DIF might lead to better identification of problematic cannabis use. As described in the results, the signed test differences (STDS) effect size, which takes into account positive and negative DIF across all items of the measure, never yielded an effect size that exceeded a full point on the CUDIT scale. As a result, the likelihood of misclassifying someone on the basis of the raw score,

using a cut score of 8 to determine problematic use, is minimal. More importantly, however, the elevated prevalence rates of problematic use among cannabis users in the ethnic minority groups relative to the Dutch group suggests that progression to problematic cannabis use may follow different trajectories within these groups. If so, additional studies could be conducted to determine whether alternative cut points may be needed in these groups to better identify individuals at risk for developing, or that have already developed, cannabis use disorder.

Though the reported findings have important implications for addressing health disparities in the prevention and intervention of cannabis use and cannabis use disorders among ethnic minority groups, the study is not without limitations. Most importantly, the study analyses were limited to men because of the low rates of cannabis use among women within and across the studied ethnic groups. As a result, the study conclusions cannot be generalized to women. The significance of this limitation cannot be understated as a recent review suggested that research into the psychometric properties of the most commonly used cannabis use measures, including the CUDIT, have failed to look for gender differences (Lopez-Pelayo et al., 2015). Additionally, given the small sample sizes of some ethnic groups (e.g., Turkish and Moroccan origin), the reported parameter estimates for the final graded response model may be subject to positive bias especially for items exhibiting significant skewness. While some simulation research has proposed that a benchmark sample size of at least 500 individuals may be needed to achieve accurate parameter estimation under the graded response model (Reise & Yu, 1990), it has also been suggested that more nuanced guidelines taking into account the ratio of sample size to the number of item parameters estimated (e.g., 5:1) can also be appropriate (De Ayala, 1994). Additionally, results from a more recent simulation study conducted using small sample sizes (n=200) and item characteristics similar to the current study indicate that potential bias in parameter estimation is likely to be relatively small (i.e., less than 10%; Forero & Maydeu-Olivares, 2009). Nonetheless, this limitation highlights the importance of replication of the current findings in larger, ethnically-diverse samples. Finally, the reported findings were correlational in nature, and thus, causal explanations for the observed differences between ethnic groups cannot be made. Prospective studies beginning earlier in development that include comprehensive assessments of relevant environmental variables will be better positioned to address these questions.

Despite these limitations, the present study suggests that, among men, the presence of DIF of CUDIT items across ethnic groups can impact the ability to detect mean differences in cannabis use severity across these groups. Consistent with prior studies, there also appears to be evidence that among cannabis users, members of ethnic minority groups are disproportionately more likely to exhibit severe use relative to the ethnic majority group (Wu, et al., 2016). Additionally, the relations between smoking and cannabis use were fairly consistent across ethnic groups, likely as a result of their shared route of administration, but only ethnic minority members showed strong correlations between severity of cannabis use and severity of alcohol use. Together, these findings suggest that prevention and intervention tailored towards ethnic minority groups with a focus on earlier contact as well as targeting alcohol co-use, may help reduce the increased rates of severe use among these groups.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Some of the data contained in the manuscript have been accepted in abstract form to the upcoming Research Society on Alcoholism's annual scientific meeting, and thus, that abstract will eventually be published. No other dissemination of the data has occurred.

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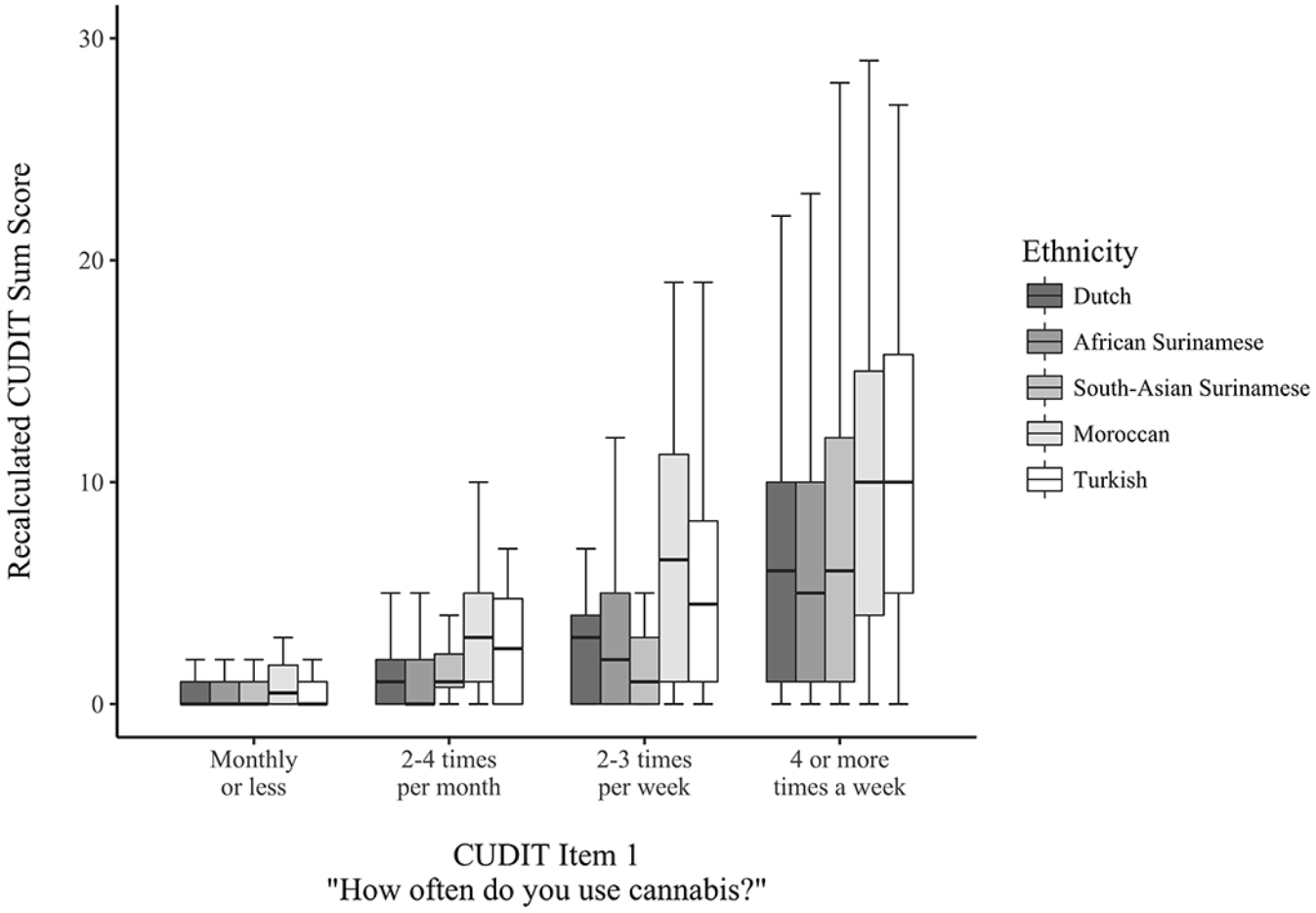

Figure 1.
Relation between the recalculated CUDIT sum score and Item 1 responses as a function of ethnic group membership.

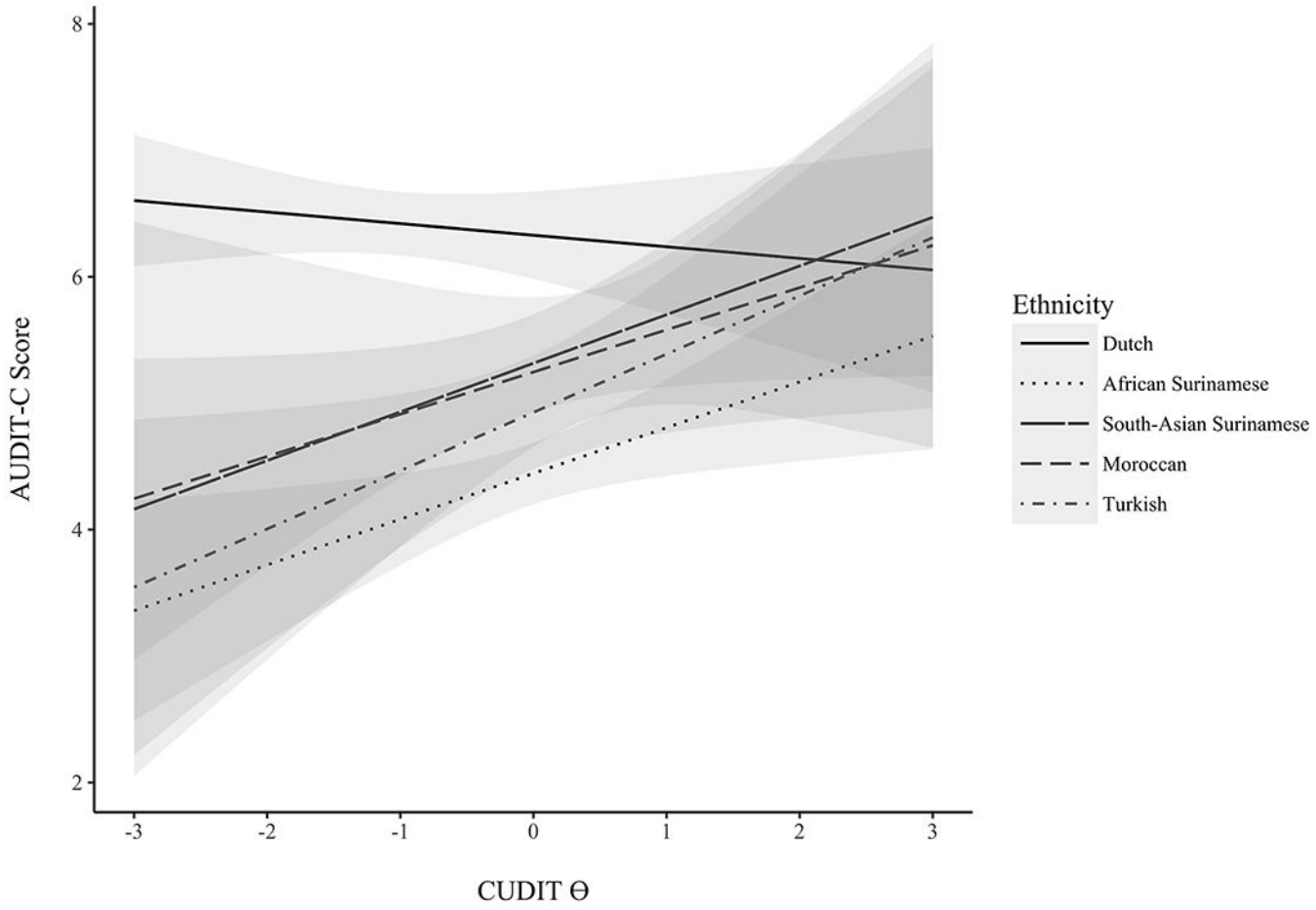

Figure 2.
Relation between cannabis and alcohol use as a function of ethnicity.

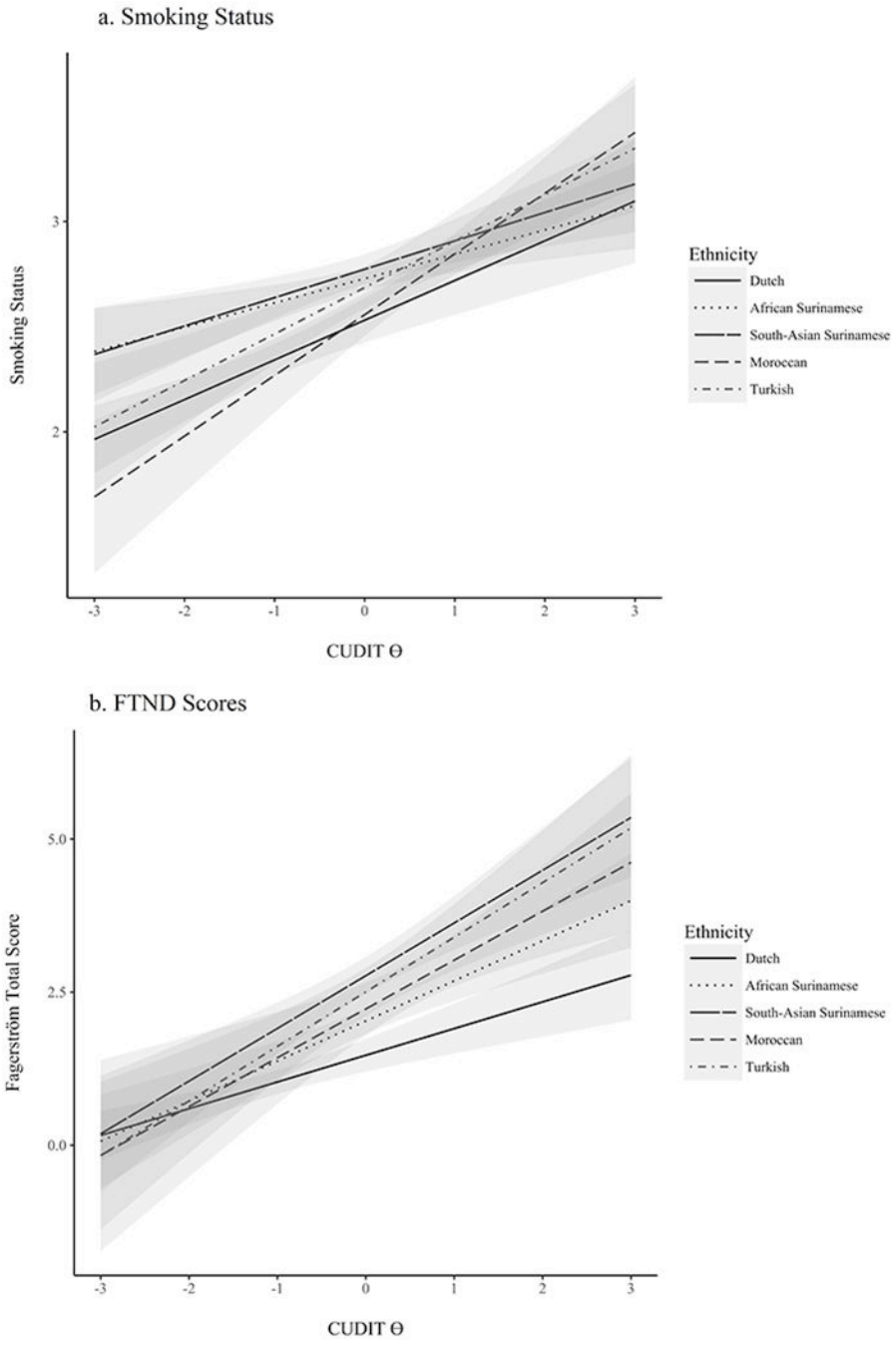

Figure 3.
Relation between cannabis and tobacco use as a function of ethnic group membership.

Table 1.

Demographic characteristics of cannabis-using participants in the HELIUS sample.

	Dutch	African Surinamese	South-Asian Surinamese	Moroccan	Turkish
n	**576**	**653**	**312**	**213**	**206**
Gender, % men	59.7	69.4	80.4	82.2	76.2
Age in years (SD)	37.1 (13.0)	42.3 (13.4)	37.4 (12.3)	32.9 (9.7)	31.9 (10.1)
CUDIT sum score (SD) (range 1-40)	4.1 (5.1)	7.3 (6.5)	8.0 (7.9)	10.5 (8.8)	7.7 (7.9)
CUDIT θ values (SD)	−1.01 (1.10)	0.00 (0.87)	−0.02 (1.03)	0.52 (0.86)	0.01 (1.04)
AUDIT-C sum score (SD) (range 1-12)	6.0 (2.4)	4.2 (2.4)	4.9 (2.8)	5.1 (2.3)	4.6 (2.5)
Smoking Status, %					
Never	18.7	9.3	9.6	9.9	10.2
Former	25.1	10.1	7.7	11.3	9.2
Current	56.2	80.7	82.7	78.8	80.6
FTND sum score (SD) (range 0-10)	1.1 (2.0)	1.9 (2.3)	2.7 (2.6)	2.4 (2.5)	2.5 (2.6)
Educational Level, %					
Low	3.3	6.5	12.9	12.7	11.8
Medium-low	13.0	37.6	33.4	23.6	28.9
Medium-high	30.1	39.1	37.0	45.3	35.8
High	53.6	16.8	16.7	18.4	23.5

Note: All numbers represent means and standard deviations unless otherwise specified. SD - standard deviation.

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Table 2.

DIF analyses of the CUDIT items as a function of ethnic group membership in cannabis users including men and women (2a) and men only (2b).

2a. Men and Women (*n*=1960)

		Omnibus Test		*a*		b_1		b_2		b_3		b_4	
Items		$\Delta\chi^2$	*p*	$\Delta\chi^2$	*p*	$\Delta\chi^2$	*p*	$\Delta\chi^2$	*p*	$\Delta\chi^2$	*p*	$\Delta\chi^2$	*p*
1	frequency of use	**31.336**	**0.012**	3.997	0.406	**10.174**	**0.038**	**11.336**	**0.023**	**10.680**	**0.030**		
2	usual hours being stoned	**35.324**	**0.004**	4.042	0.400	**11.120**	**0.025**	1.871	0.759	2.235	0.693	2.082	0.721
3	stoned for 6 or more hours	**35.329**	**0.004**	0.744	0.946	3.204	0.524	1.034	0.905	1.656	0.799	2.548	0.636
4	not able to stop	-	-	-	-	-	-	-	-	-	-	-	-
5	failed to do what expected	**42.917**	**<0.001**	3.815	0.432	3.917	0.417	3.944	0.414	3.717	0.446	5.895	0.207
6	morning use	-	-	-	-	-	-	-	-	-	-	-	-
7	guilt/remorse	**102.124**	**<0.001**	0.991	0.911	**14.411**	**0.006**	6.066	0.194	4.969	0.290	6.910	0.141
8	memory/concentration problems	**69.993**	**<0.001**	2.743	0.602	9.318	0.054	2.389	0.665	1.261	0.868	3.256	0.516
10	concerned others	-	-	-	-	-	-						

2b. Men only (*n*=1380)

		Omnibus Test		*a*		b_1		b_2		b_3		b_4	
Items		$\Delta\chi^2$	*p*	$\Delta\chi^2$	*p*	$\Delta\chi^2$	*p*	$\Delta\chi^2$	*p*	$\Delta\chi^2$	*p*	$\Delta\chi^2$	*p*
1	frequency of use	**41.297**	**0.001**	6.123	0.190	**15.418**	**0.004**	**16.740**	**0.002**	**15.326**	**0.004**		
2	usual hours being stoned	**33.707**	**0.006**	4.244	0.374	8.175	0.085	1.813	0.770	3.214	0.523	4.751	0.314
3	stoned for 6 or more hours	**29.482**	**0.021**	1.389	0.846	3.637	0.457	2.120	0.714	2.769	0.597	3.615	0.461
4	not able to stop	-	-	-	-	-	-	-	-	-	-	-	-
5	failed to do what expected	**32.158**	**0.010**	3.690	0.450	3.469	0.483	4.039	0.401	3.613	0.461	4.592	0.332
6	morning use	-	-	-	-	-	-	-	-	-	-	-	-
7	guilt/remorse	**84.926**	**<0.001**	1.038	0.904	9.137	0.058	4.198	0.380	3.592	0.464	5.261	0.262
8	memory/concentration problems	**55.025**	**<0.001**	1.242	0.871	5.807	0.214	0.958	0.916	0.538	0.970	2.682	0.612
10	concerned others	-	-	-	-	-	-						

Note: $\Delta\chi^2$ – change in chi-square statistic between models freely estimating and constraining parameters to be equal; *a* - discrimination parameter; $b_{1\text{-}4}$ - difficulty parameters for transition between response levels for each item; bold text indicates nominal significance at $p<0.05$. Results for women only are not presented due to low numbers of female cannabis users. Items 4, 6, and 10 were selected as anchor items, and thus were not tested for DIF

Table 3.

DIF analyses of the CUDIT items in cannabis users as a function of gender (n=1960).

		Omnibus Test		*a*		b_1		b_2		b_3		b_4	
Items		**$\Delta\chi^2$**	***p***	**$\Delta\chi^2$**	***p***	**$\Delta\chi^2$**	***p***	**$\Delta\chi^2$**	***p***	**$\Delta\chi^2$**	***p***	**$\Delta\chi^2$**	***p***
1	frequency of use	5.388	0.250	0.741	0.389	**4.060**	**0.044**	2.222	0.136	3.079	0.079		
2	usual hours being stoned	1.883	0.757	1.377	0.241	1.680	0.195	1.504	0.220	1.076	0.300	2.804	0.094
3	stoned for 6 or more hours	-	-	-	-	-	-	-	-	-	-	-	-
4	not able to stop	**13.559**	**0.009**	2.161	0.142	**6.636**	**0.010**	**7.644**	**0.006**	**5.618**	**0.018**	1.867	0.172
5	failed to do what expected	**22.553**	**<0.001**	0.437	0.509	0.388	0.533	0.028	0.867	2.415	0.120	**5.989**	**0.014**
6	morning use	-	-	-	-	-	-	-	-	-	-	-	-
7	guilt/remorse	3.905	0.419	0.493	0.483	2.193	0.139	1.201	0.273	1.821	0.177	0.158	0.691
8	memory/concentration problems	**16.105**	**0.003**	1.688	0.194	**8.977**	**0.003**	**7.552**	**0.006**	**7.390**	**0.007**	**4.641**	**0.031**
10	concerned others	1.947	0.378	0.058	0.810	0.588	0.443						

Note: $\Delta\chi^2$ – change in chi-square statistic between models freely estimating and constraining parameters to be equal; *a* - discrimination parameter; $b_{1\text{-}4}$ - difficulty parameters for transition between response levels for each item; bold text indicates nominal significance at p<0.05. Items 3 and 6 were selected as anchor items, and thus were not tested for DIF.

Table 4.

Regression of alcohol use (AUDIT-C sum scores) on cannabis use (IRT-derived CUDIT θ scores), ethnicity, and their interaction (n=1139).

	b	**SE**	***t***	***p***
CUDIT θ values	−0.12	0.13	−0.91	0.36273
African Surinamese ethnicity	**−1.05**	**0.26**	**−3.99**	**7.13E-05**
South-Asian Surinamese ethnicity	**−1.97**	**0.23**	**−8.44**	**2.00E-16**
Turkish ethnicity	**−1.38**	**0.30**	**−4.64**	**3.89E-06**
Moroccan ethnicity	**−1.07**	**0.38**	**−2.84**	**0.00456**
Age	0.01	0.01	0.97	0.33153
Educational Level	−0.09	0.09	−1.02	0.30648
CUDIT θ values x African Surinamese ethnicity	**0.49**	**0.21**	**2.35**	**0.01900**
CUDIT θ values x South-Asian Surinamese Ethnicity	**0.46**	**0.19**	**2.36**	**0.01823**
CUDIT θ values x Turkish ethnicity	**0.56**	**0.24**	**2.30**	**0.02168**
CUDIT θ values x Moroccan ethnicity	0.43	0.35	1.22	0.22362
R^2	0.111			

Note: All ethnicity variables are binary and coded to indicate Dutch ethnicity as the reference group. AUDIT-C scores served as the dependent variable. Age and educational level were included as covariates. Bolded text indicates significant effect at p<0.05.

Table 5.

Regression of (a) smoking status and (b) nicotine dependence (FTND sum score) on cannabis use (IRT-derived CUDIT θ scores), ethnicity, and their interaction.

5a. Smoking Status (*n*=1368)

	b	SE	*z*	*p*
CUDIT θ values	**0.55**	**0.07**	**7.37**	**1.71E-13**
African Surinamese ethnicity	**0.78**	**0.22**	**3.55**	**0.000392**
South-Asian Surinamese Ethnicity	**0.41**	**0.19**	**2.20**	**0.027497**
Turkish ethnicity	**0.56**	**0.24**	**2.29**	**0.022279**
Moroccan ethnicity	0.25	0.25	0.99	0.323682
Educational Level	**−0.38**	**0.08**	**−4.53**	**5.93E-06**
Age	**0.02**	**0.01**	**4.35**	**1.38E-05**
Nagelkerke R^2	0.211			

5b. FTND Scores (*n*=1350)

	b	SE	*z*	*p*
CUDIT θ values	**0.62**	**0.06**	**9.90**	**2.00E-16**
African Surinamese ethnicity	**0.91**	**0.20**	**4.58**	**5.12E-06**
South-Asian Surinamese ethnicity	−0.05	0.18	−0.27	0.784768
Turkish ethnicity	**0.82**	**0.23**	**3.59**	**0.000346**
Moroccan ethnicity	**0.62**	**0.23**	**2.68**	**0.007373**
Educational Level	**−0.30**	**0.07**	**−4.12**	**4.07E-05**
Age	**0.03**	**0.00**	**7.04**	**3.07E-12**
R^2	0.195			

Note: All ethnicity variables are binary and coded to indicate Dutch ethnicity as the reference group. Smoking status and nicotine dependence as assessed by FTND sum score served as the dependent variable in Tables 5a and 5b, respectively. Age and educational level were included as covariates. Bolded text indicates significant effect at $p<0.05$.