Differential criterion functioning of alcohol use symptomatology in major depressive disorder?

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Background. Major depressive disorder (MDD) and alcohol use disorders (AUDs) are among the most prevalent psychiatric disorders and are frequently co-morbid. However, some component of this co-morbidity may be artifactual and arise from the influence of current mental state on self-reports of AUD.

Method. This study examined whether past-year MDD is associated with differential criterion functioning (DCF) in reports of AUD symptomatology in male and female participants in the National Epidemiological Survey on Alcohol and Related Conditions (NEASRC).

Results. Reports of past-year AUD symptomatology were adequately summarized by a single-factor model in which each of the 11 abuse and dependence criteria had high factor loadings (0.71–0.93) and did not vary between men and women after allowing for threshold differences. Co-morbid MDD was associated with higher AUD mean scores. There was some evidence for DCF with past-year MDD being associated with a lower endorsement of use in hazardous situations among men whereas women with MDD were more likely to endorse both social/interpersonal problems and emotional/physical problems.

Conclusions. Several items assessing AUD display DCF in the presence of MDD. While these findings highlight the need to consider the possibility that mental state can influence reporting of psychiatric symptoms and potentially inflate estimates of co-morbidity, they suggest that only a negligible component of the co-morbidity between MDD and AUDs can be attributed to over-reporting of alcohol symptomatology conditional on current MDD.

Introduction

Major depressive disorder (MDD) and alcohol use disorders (AUDs; abuse and dependence) are among two of the most commonly diagnosed psychiatric disorders in large-scale epidemiological surveys of the general population. For example, the recent National Epidemiological Survey of Alcohol and Related Conditions (NESARC) estimated that 13.23% of the US general population met lifetime criteria for MDD (Hasin *et al.* 2005) and that 30.3% met lifetime criteria for an AUD (Compton *et al.* 2005). There is also considerable co-morbidity between these conditions and numerous studies have reported elevated rates of MDD in those meeting criteria for AUD and elevated rates of AUD in those meeting criteria for MDD, with estimates suggesting that rates of AUD are in the region of two to three times higher in people meeting criteria for MDD (Spaner *et al.* 1994; Grant & Harford,

1995; Ross, 1995; Kessler *et al.* 1996; see Lynskey, 1998 for a review of this literature). More recently, Grant *et al.* (2004) reported that a past-year diagnosis of MDD was associated with a 2.3-fold increase in odds of meeting criteria for an AUD.

Although the co-morbidity between these conditions is well established, Caron & Rutter (1991) highlighted the need to distinguish between 'true' co-morbidity and artifactual co-morbidity, which may arise through a variety of processes including sample selection or referral biases and item contamination whereby similar or identical symptoms are used to form the basis of a diagnosis of multiple disorders. A further, though perhaps more subtle, issue concerns the extent to which the experience of one disorder may alter reporting of symptoms for another. Specifically, it could be argued that depressive symptomatology may lead to an exaggeration or over-reporting of negative symptoms of AUD, and particularly those relating to interpersonal functioning.

Although we are unaware of any published research that has explicitly addressed this issue, there are several lines of evidence supporting such a possibility.

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First, there has been considerable interest in the child and adolescent psychiatric literature in the extent to which parental, and particularly maternal, ratings of child behavior problems may be influenced by parental depression. Specifically, some commentators have suggested that the elevated rates of child problem behaviors in the offspring of depressed parents may be artifactual and arise from depression influencing parental ratings (see Richters, 1992 for a review of this and competing hypotheses). While the weight of the evidence suggests that rates of offspring problem behaviors are elevated in the offspring of depressed parents, there is also evidence, derived principally from studies using multiple informant data, that parental mental state does influence parental ratings of offspring behavior and, in particular, leads to an over-reporting of negative behaviors (Fergusson *et al*. 1993; Renouf & Kovacs, 1994; Briggs Gowan *et al*. 1996; Hay *et al*. 1999; Najman *et al*. 2001; Kroes *et al*. 2003; De Los Reyes & Kazdin, 2005).

Analogous results have been reported by Wells & Horwood (2004), who found that current depressed mood influenced recall of lifetime depressive symptomatology. Specifically, while retrospective reports collected at age 25 dramatically under-estimated the prevalence of depression, relative to prospective data on symptomatology, currently experiencing key symptoms of depression (2 weeks or more of sadness/depression or loss of interest) was associated with a significant increase in the recall of depressive symptoms (from 42% to 61%) and this effect persisted even after control for the (prospectively assessed) severity and chronicity of lifetime depression. Thus, there are two distinct areas of research in which current depressive symptomatology has been shown to influence reporting of symptoms either personally experienced or observed in others (i.e. offspring).

Extrapolating from these findings it is reasonable to hypothesize that MDD may be associated with elevated rates of reporting of negative symptoms associated with alcohol dependence. One potential methodology to explore this issue involves the application of methods of differential criterion functioning (DCF) to examine whether MDD influences criterion behavior, independently of any association between MDD and AUD. In this study we applied such methods to data on past-year MDD and AUD in a large and representative sample of the US general population, the NESARC (Grant *et al*. 2003*b*).

One important issue to consider when applying these methods to study the influence of MDD on ratings of AUD symptomatology concerns the possible influence of gender. Specifically, there are substantial, yet opposing, gender differences in the prevalence of these disorders, with AUDs being more common in men than in women (e.g. lifetime prevalence estimates of 42% and 19.5% respectively in NESARC; Compton *et al*. 2005), whereas MDD is more common in women than in men (e.g. NESARC estimated that 17.1% of women and 9.01% of men meet lifetime criteria for an MDD; Hasin *et al*. 2005). Furthermore, there is recent evidence to suggest that there are systematic sex differences in the criterion functioning of alcohol abuse and dependence criteria. Thus, Saha *et al*. (2006) recently reported that, within an item response theory (IRT) framework, although test response curves did not vary significantly between males and females, several criteria exhibited significant DCF by sex. DCF refers to the influence of a covariate, such as co-occurring MDD, on items/criteria constituting a factor (e.g. alcohol dependence), after accounting for the direct influence of the covariate on that factor. Taken together, this evidence suggests that, when considering the potential influence of MDD on ratings of AUD symptomatology, it is important to consider the potential influence of gender. Thus, in this paper, we examined the influence of MDD on AUD criteria separately in men and women.

Method

Sample

We used data from the NESARC. Interviews were conducted by the US Bureau of the Census, on behalf of the National Institute on Alcohol Abuse and Alcoholism (Grant *et al*. 2003*b*), on 43 093 individuals, including adult, non-institutionalized US citizens and non-citizens (including Alaska and Hawaii) during the first wave (2001–2002) of this longitudinal survey. The sample includes data from 18 518 (43%) men and 24 575 women with a mean age of 46.4 years [standard deviation (S.D.)=18.2]. The sample is racially diverse (19% ethnically Hispanic and multi-racial identifications of 76% White, 20% Black/African American, 0.8% Native Hawaiian/Pacific Islander, 3.1% Asian, 3.0% American India/Alaskan Native) with over-sampling for non-Hispanic Black households and for young adults aged 18–24 years (see Grant *et al*. 2003*b*, page 6, for details). All US census regions (Northeast: 19%; Midwest: 21%; South: 38%; West: 22%) were used. Complete details regarding the sampling strategy, study design and estimation of weights for generalizability are presented on the website for the NESARC data (Grant *et al*. 2003*b*) (http://niaaa.census.gov/pdfs/source_and_accuracy_statement.pdf). After complete description of the study to the subjects, informed consent was obtained. Statements regarding the strict confidentiality of respondent information are available at http://niaaa.census.gov/confidentiality.html.

For the current analyses, we excluded all participants who were not current regular alcohol users (i.e. did not report having at least 12 alcoholic drinks in the past 12 months). Consequently, our sample consisted of 11 200 men and 9636 women with past-year regular alcohol use.

Assessment of DSM-IV (APA, 1994) criteria of past-year alcohol abuse and dependence were made using the Alcohol Use Disorder and Associated Disabilities Interview (AUDADIS; Grant *et al.* 2003*a*), which has been shown to have high reliability for diagnoses of substance use disorders. The following criteria were coded: for abuse, (i) Legal (legal problems/getting arrested); (ii) Failure (failure to fulfill major role obligations); (iii) Hazard (use in hazardous situations); and (iv) Social/interpersonal (continued use despite trouble with friends or family); and for dependence, (i) Tolerance; (ii) Withdrawal; (iii) Larger/longer (using larger amounts/for longer than intended); (iv) Important activities (give up or cut down on important activities); (v) Emotional/physical problems (use of drug despite health/psychological problems); (vi) Time spent (spent time getting or using drug); and (vii) Difficulty quitting (more than once trying to stop or cut down use of drug).

Past-year DSM-IV MDD was coded as a dichotomous diagnosis. Diagnoses that were substance or illness induced were excluded.

Statistical analyses

We used the one-factor confirmatory factor model (CFM), parameters from which easily translate to the item response framework, with factor loadings representing item (or, as in our case, criterion) discrimination (or how well a criterion measures the underlying vulnerability to AUD) and thresholds (i.e. prevalence of the criterion) denoting criterion discrimination (or the location along the AUD liability distribution where the criterion functions). Differential item/criterion functioning (DCF; Muthen & Lehman, 1985) is a formal test of whether the factor loading/ discrimination and the threshold/difficulty of certain criteria vary across subgroups of individuals, such as men and women, or in individuals with co-occurring MDD. A criterion is said to exhibit DCF if there is a difference in either the difficulty (i.e. likelihood of endorsement) or discrimination (i.e. factor loading) of a criterion in the presence or absence of a covariate, over and above any association between the covariate and the latent construct underlying the criteria. It is classically used in the context of educational testing to examine the total variance in the underlying factor attributable to individual testing items using a variety of traditional statistical tests, including the

Mantel–Haenszel procedure (Linacre & Wright, 1987). In the current context, if, for example, men are more likely to endorse hazardous alcohol use (i.e. lower threshold) than women, even after accounting for mean differences in AUD scores across genders, then we might say that hazardous use is a more difficult item for women than men, and hence shows DCF with respect to difficulty. Relatedly, if the factor loading of a criterion is greater in individuals with MDD *versus* those without, we might say that the criterion discriminates better in individuals with MDD, and hence shows DCF with respect to discrimination.

MPlus version 4.1 (Muthen & Muthen, 2006) was used to perform four-group modeling. Analyses were performed with men and women further stratified as reporting a history of past 12-month MDD or not (MDD+, MDD−) into groups using the *knownclass* (which specifies that parameters, including thresholds and factor loadings, should be modeled separately in men and women, who are defined, and not estimated, to be in different classes) option. First, we fit a one-factor CFM, with factor loadings and thresholds constrained across all four groups: Male MDD−, Female MDD−, Male MDD+, Female MDD+. Variances were constrained in each group to 1.0 to identify the model where all factor loadings were estimated, while factor means were allowed to vary. Second, an equality of means was tested by constraining the means across sexes and MDD status to be equal. Third, thresholds for the 11 abuse and dependence items were individually constrained across all four groups. Fourth, factor loadings for the 11 criteria were individually equated across all four groups. The final series of models tested whether, after accounting for threshold differences, there was any evidence for differences in factor loadings.

Analyses were conducted using the maximum likelihood ratio (MLR) estimator, which uses a χ^2 statistic similar to the Yuan–Bentler T2 statistic, which is robust to non-normality and non-independence of observations. Model fit was compared using likelihood-based fit statistics. The Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI) and Tucker Lewis Index (TLI) are currently unavailable for complex survey data. Options for clustering (by primary sampling unit), stratification (by stratum) and weighting were used to allow generalization of these results to the US population. These procedures for complex survey data have been demonstrated to be applicable to DCF tests in NESARC (Saha *et al.* 2006). NESARC oversampled for 18–24-year-olds (sampled at $2.25 \times$ the other age groups) and for Hispanics (12.5–19.3%) and for non-Hispanic Blacks (12.3–19.1%). The final weights are a combination of the base weight, defined as the product
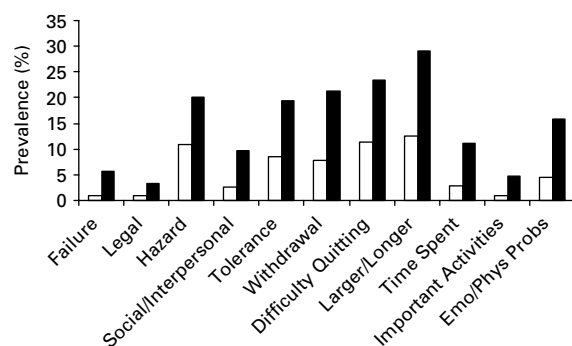
Fig. 1. Prevalence of past-year DSM-IV alcohol abuse and dependence criteria, stratified by a past-year diagnosis of major depressive disorder (MDD) in 20 836 past-year regular alcohol users. □, No MDD; ■, MDD.

of the conditional probabilities of selection in the first two sampling stages (across and within primary housing/sampling units or PSUs) and other individual weighting factors. In MPlus, weighting in complex survey designs is done by using pseudo-maximum likelihood, which in simulations has been shown to produce unbiased parameter estimates (for details, see Asparouhov, 2005).

Results

MDD and rates of alcohol symptom endorsement

Of the 43 093 participants in NESARC, about 81% reported lifetime alcohol use (i.e. at least one full drink), while 20 836 participants (60% of lifetime users) reported current regular use (i.e. drinking at least 12 alcoholic drinks in the past 12 months). The mean age of regular alcohol users was 42.6 years (54% male). The prevalence of past-year MDD in this sample was 7.7% ($n = 1614$, 64.4% female). DSM-IV-defined alcohol dependence was significantly elevated in both males [odds ratio (OR) 2.56, 95% confidence interval (CI) 2.14–3.07] and females (OR 2.82, 95% CI 2.37–3.36) who met criteria for MDD.

Fig. 1 shows the distribution of individual past-year alcohol abuse and dependence criteria in regular alcohol users according to whether or not they met criteria for MDD. This figure shows substantial differences in the prevalence of each of the 11 DSM-IV alcohol abuse and dependence criteria according to whether or not an individual met criteria for comorbid MDD: a diagnosis of MDD was associated with a 2.5- to 7.6-fold increase in the odds of reporting each of these symptoms.

Table 1 presents the past-year prevalence of individual DSM-IV criteria, stratified by gender and a past-year diagnosis of MDD. Men, in general, had higher rates of criterion endorsement than women,

irrespective of MDD status. However, in both men and women, those with a diagnosis of MDD were more likely to endorse individual criteria than their counterparts who did not meet criterion for past-year MDD. Note that the prevalence of these criteria in past-year regular users has also been reported in Saha *et al.* (2006, 2007).

Factor analysis of alcohol abuse and dependence criteria

Saha *et al.* (2006) have previously demonstrated that a single-factor solution best describes the relationship between past-year DSM-IV alcohol abuse and dependence criteria. Similarly, in our analyses, a one-factor model, with thresholds and factor loadings constrained across men and women and free means, provided a good fit to the data [-2 log likelihood $= -59359.04$ for 28 parameters, likelihood ratio χ^2 fit $= 3197.27$ for 8144 degrees of freedom (df)]. Note that variances were constrained to be 1.0 to freely estimate all 11 factor loadings. We tested for equality of variances by constraining the factor loading for tolerance to 1.0, and allowing for freely estimated variances; there was no evidence for inequality of variances ($\Delta\chi^2 = 1.42$ for 3 df). Next, keeping factor loadings and thresholds equal, we tested for equality of means of the AUD factor score; this was not statistically supported ($\Delta\chi^2 = 364.6$ for 2 df) and means were allowed to vary in the all groups (with the Male MDD$-$ as the reference group). Constraints on thresholds were then imposed across groups. Thresholds for Legal could not be constrained across sexes, but could be constrained across MDD status. By contrast, thresholds for the remaining abuse items of Failure, Hazard and Social/interpersonal could not be constrained across gender or MDD status. Men were more likely than women to endorse hazardous use, especially men without co-occurring MDD, while recurring social/interpersonal problems were most commonly reported by women with MDD. Significant effects of gender (but not MDD status) were seen for thresholds of dependence criteria of Withdrawal (lower in women) and Larger/longer (lower in women). Allowing for these different thresholds (i.e. varying rates of criterion endorsement) led to a significant improvement in fit ($\Delta\chi^2 = 115.04$ for 7 df) in an omnibus test. After allowing thresholds for Withdrawal (higher in men, where a *higher* threshold means *lower* likelihood of endorsement), Larger/Longer (higher in men), Legal (higher in women), Hazard (higher in women) and Social/Interpersonal, there was statistical evidence for differential factor loadings for Failure, across gender but not MDD status, only ($\Delta\chi^2 = 4.5$ for 1 df). The final model fit the

Table 1. *Prevalence of past-year DSM-IV alcohol abuse and dependence criteria, stratified by a past-year diagnosis of major depressive disorder (MDD) and by gender*

Alcohol abuse/ dependence criteria	Men		Women	
	MDD	No MDD	MDD	No MDD
Failure	8.4	1.2	4.2	0.8
Legal	5.4	1.5	2	0.3
Hazard	28.1	14.2	15.7	6.7
Social/interpersonal	15.7	3.5	6.5	1.3
Tolerance	26.7	10.2	15.5	6.2
Withdrawal	25.1	8.6	19.2	6.7
Difficulty quitting	28.9	13.8	20.4	8.4
Larger/longer	35.5	14.4	25.6	10.3
Time spent	16.6	3.7	8.2	1.7
Important activities	7.5	1.2	3.2	0.5
Emotional/physical problems	21.4	5.6	12.6	2.9
n	574	10 626	1040	8596

Table 2. *Raw parameter estimates, with their 95% confidence intervals, for the final model with varying thresholds and factor loadings*

Alcohol abuse/ dependence criteria	Factor loadings	Thresholds			
		Men		Women	
		MDD−	MDD+	MDD−	MDD+
Failure	M: 4.21 (3.51–4.91) F: 4.49 (3.73–5.25)	9.52 (7.81–11.23)	9.52 (7.81–11.23)	11.34 (9.32–13.36)	12.08 (9.55–14.60)
Legal[a]	1.93 (1.71–2.15)	5.83 (5.43–6.23)	5.83 (5.43–6.23)	6.38 (5.89–6.87)	6.38 (5.89–6.87)
Hazard[a]	1.80 (1.68–1.91)	2.61 (2.46–2.77)	3.06 (2.75–3.37)	3.12 (2.95–3.29)	3.12 (2.95–3.29)
Social/interpersonal[a]	3.00 (2.72–3.28)	6.23 (5.79–6.66)	6.23 (5.79–6.66)	6.78 (6.26–7.31)	6.21 (5.59–6.84)
Tolerance	2.19 (2.05–2.32)	3.55 (3.39–3.72)	3.55 (3.39–3.72)	3.55 (3.39–3.72)	3.55 (3.39–3.72)
Withdrawal[a]	2.56 (2.40–2.72)	4.21 (3.99–4.44)	4.21 (3.99–4.44)	3.70 (3.48–3.91)	3.70 (3.48–3.91)
Difficulty quitting	1.82 (1.70–1.93)	2.82 (2.68–2.95)	2.82 (2.68–2.95)	2.82 (2.68–2.95)	2.82 (2.68–2.95)
Larger/longer[a]	2.80 (2.62–2.97)	3.45 (3.26–3.64)	3.45 (3.26–3.64)	3.08 (2.87–3.30)	3.08 (2.87–3.30)
Time spent	3.70 (3.40–4.01)	7.32 (6.84–7.80)	7.32 (6.84–7.80)	7.32 (6.84–7.80)	7.32 (6.84–7.80)
Important activities	4.07 (3.58–4.56)	9.92 (8.98–10.86)	9.92 (8.98–10.86)	9.92 (8.98–10.86)	9.92 (8.98–10.86)
Emotional/physical problems	3.24 (2.96–3.51)	5.78 (5.27–6.20)	5.78 (5.27–6.20)	5.78 (5.27–6.20)	5.78 (5.27–6.20)

MDD, Major depressive disorder; F, female; M, male.

[a] Thresholds free across genders.

data well (likelihood ratio χ^2 fit = 2963.09 for 8134 df). The model fit was also satisfactory (likelihood ratio χ^2 fit of 2626.48 for 8130 df) when sampling weights were not applied. The unstandardized factor loadings and thresholds are presented in Table 2, and standardized loadings and thresholds are shown in Table 3.

Discussion

In this paper we have applied methods of DCF to data from a large and representative sample of the US general population to examine the extent to which reports of DSM-IV alcohol abuse and dependence symptoms may be influenced by current (past-year) MDD, independently of any association between MDD and vulnerability to AUDs. The results of these analyses, and their implications, are discussed below.

First, in confirmation of a large existing literature, there were moderate associations between MDD and alcohol-related problems, with these associations being of similar magnitude in both women and men (Spaner *et al.* 1994; Grant & Harford, 1995; Ross, 1995;

Table 3. *Standardized factor loadings and thresholds for four-group factor model of alcohol abuse and dependence criteria, including standardized factor loadings and thresholds that varied by gender*

Alcohol abuse/ dependence criteria	Factor loadings	Thresholds			
		Men		Women	
		MDD−	MDD+	MDD−	MDD+
Failure	0.93 (F); 0.92 (M)	2.18	2.18	2.01	2.14
Legal[a]	0.73	2.20	2.20	2.41	2.41
Hazard[a]	0.70	1.02	1.20	1.22	1.22
Social/interpersonal[a]	0.86	1.77	1.77	1.93	1.78
Tolerance	0.77	1.25	1.25	1.25	1.25
Withdrawal[a]	0.82	1.34	1.34	1.18	1.18
Difficulty quitting	0.71	1.10	1.10	1.10	1.10
Larger/longer[a]	0.84	1.03	1.03	0.92	0.92
Time spent	0.90	1.78	1.78	1.78	1.78
Important activities	0.91	2.23	2.23	2.23	2.23
Emotional/physical problems	0.87	1.56	1.56	1.56	1.56

MDD, Major depressive disorder; F, female; M, male.

[a] Thresholds free across genders.

Kessler *et al.* 1996; Lynskey, 1998; Grant *et al.* 2004). Preliminary consideration of rates of endorsement for individual abuse and dependence criteria indicated that endorsement of each of the 11 DSM-IV criteria was elevated in those meeting criteria for MDD, suggesting that previously observed elevations in rates of AUDs in those meeting criteria for MDD could not be attributed to the influence of MDD on only a small subset of the abuse/dependence criteria.

However, examination of differential criterion function indicated that men with MDD were less likely to endorse use in hazardous situations whereas women with MDD were more likely to endorse both social/interpersonal problems and emotional/physical problems. These results parallel literature reports indicating that parental mental state may influence reports of offspring psychopathology (Fergusson *et al.* 1993; Renouf & Kovacs, 1994; Briggs Gowan *et al.* 1996; Hay *et al.* 1999; Kroes *et al.* 2001; De Los Reyes & Kazdin, 2005) and that current depression may influence retrospective reports of depressive symptomatology (Wells & Horwood, 2004). Although the magnitude of these effects was relatively small, they suggest that there may be different symptom profiles in individuals self-referred to treatment for AUD according to whether or not they are experiencing depressive symptomatology. Such differences reinforce previous calls for the comprehensive assessment of psychopathology in alcohol dependence treatment and for the development of treatment approaches addressing co-occurring substance dependence and other mental disorders (O'Brien *et al.* 2004). Although

it remains possible that reporting biases may lead to a slight overestimation of the association between MDD and AUDs, specifically in women, our findings suggest that the observed associations between MDD and AUDs are not artifactual and probably represent true co-morbidity.

There has been considerable speculation in the literature as to possible mechanisms underlying this co-morbidity and it appears likely that there is a combination of contributing factors. These include the influence of shared risk factors, including genetic vulnerabilities, that act to increase the risks of both MDD and AUDs. Specifically, family psychiatric history has been shown to be a stronger predictor of co-morbid depression and alcohol dependence than of either condition in isolation (Dawson & Grant, 1998), and a number of twin, adoption and extended family studies have reported significant genetic correlations between MDD and AUD (Cloninger *et al.* 1979; Wender *et al.* 1986; Coyrell *et al.* 1992; Kendler *et al.* 1993; Prescott *et al.* 2000), although such correlations have not been universally reported (Goodwin *et al.* 1973, 1977; Gershon *et al.* 1982; Merikangas *et al.* 1985) and, more recently, it has been suggested that the genetic correlation between MDD and AUD can be explained by the shared genetic influence of antisocial personality disorder (Fu *et al.* 2002). Other explanations for the observed co-morbidity between MDD and AUD include the possibility that AUDs may induce MDD (Brown & Schuckit, 1988; Brook *et al.* 2002; Ramsey *et al.* 2004; Schuckit, 2006) or conversely that MDD may induce AUDs

through processes such as self-medication (Deykin *et al.* 1987; Khantzian, 1997; Kuo *et al.* 2006). Neale & Kendler (1995) have proposed a series of etiological models of co-morbidity that can be tested using twin- or other family-based designs, and it is important to recognize that there may be multiple causal pathways contributing to the observed co-morbidity between MDD and AUD or that there may be etiological heterogeneity in the factors underlying this co-morbidity (Schuckit, 2006).

Several limitations of this study are noteworthy. First, all data were based on retrospective reports of both MDD and AUDs. However, by limiting our analyses to reports of symptomatology occurring in the past 12 months, we have probably substantially reduced recall bias. Second, we used a diagnostic (affected/unaffected) assessment of DSM-IV MDD. An alternative approach would have been to test a factor model for MDD. Aggen *et al.* (2005) have demonstrated that the risk underlying symptoms of MDD are unidimensional and have noted that diagnostic status is less informative than scale scores. Additionally, Fergusson *et al.* (2005) have demonstrated that subthreshold depression during adolescence is predictive of subsequent MDD and suicidal behaviors and have argued that depressive symptoms are more adequately represented as falling along a continuum of severity. However, NESARC only assessed lifetime occurrence of individual MDD symptoms, and episodes were only assessed for the past 12 months, and prior to the past 12 months. Hence, we do not have the data necessary to fit a past 12-month MDD factor that would be comparable to the past 12-month AUD factor, for which each symptom was assessed in the past 12 months. We prefer not to generalize MDD to a lifetime diagnosis, as experiencing MDD several years ago may have relatively little impact on the reporting of past 12-month AUD symptoms. Third, we chose to stratify by sex when testing for criterion performance, although such group differences in thresholds or factor loadings may also exist by age, and possibly by ethnicity. Saha *et al.* (2006) have shown lower discrimination in older individuals (aged 25–44 years and 45 and older) when compared to 18- to24-year-olds, but did not find clear evidence for criterion differences due to ethnicity.

Although comparable in most regards with previously published item response models by Saha and colleagues (2006, 2007), our factor analyses are more analogous to the latter manuscript by this group (Saha *et al.* 2007), where factor analyses were performed on past-year regular users and where the Legal criterion was retained in model fitting. The initial IRT modeling reported by Saha *et al.* (2006) subset on regular alcohol users who also reported having ever consumed 5+ drinks on a single occasion ($n = 22\,526$) and also excluded Legal from the models used for DCF, due to an improvement in model fit upon dropping the criterion (factor loading 0.67). In our analyses (which subset on regular use only), the factor loading for Legal was 0.74, and we therefore retained this criterion in subsequent models. Notwithstanding this difference, we identified threshold differences (or changes in difficulty) across sexes for the same criteria as Saha *et al.* (2006). However, after accounting for these threshold differences, we found no further evidence for sex differences in factor loadings.

In summary, our analyses suggest that past-year MDD may lead to slight biases in reporting of some specific alcohol abuse and dependence criteria. Nonetheless, even after allowing for such potential biases, strong associations remained between MDD and AUD symptoms, confirming previous reports of a high degree of co-morbidity between these conditions. Further research is needed to understand the origins of this co-morbidity and how the experience of one disorder may alter or exacerbate the clinical course of the other.

Declaration of Interest

None.

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