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The Latent Structure of Marijuana and Cocaine Use Disorders: Results from the National Longitudinal Alcohol Epidemiologic Survey (NLAES)

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Abstract

To better understand the underlying concepts of substance dependence and abuse, the present study examines the factor structure of DSM-IV lifetime criteria for cannabis and cocaine use disorders. Data for this study were drawn from the National Longitudinal Alcohol Epidemiologic Survey (NLAES), a large nationally representative U.S. sample aged 18 years and older. Exploratory factor analysis (EFA) examined the factor structure for each substance and the factors were related to background covariates using latent variable modeling techniques. Separate analyses were conducted for lifetime marijuana and cocaine users. A two-factor solution was identified for each substance and was similar to DSM-IV abuse and dependence. The factors were highly correlated for both cannabis (r = .73) and cocaine (r = .77). Background variables accounted only for a modest amount of factor variance. In conjunction with the findings in alcohol use disorders, these results support the use of consistent criteria across substances in DSM-IV and ICD-10, and suggest that the consistent finding of two correlated factors across substances needs to be better understood.

Keywords

Cocaine; Marijuana; Factor Analysis; Nosology

1. Introduction

The prevention and treatment of substance use disorders should be improved by better understanding their etiology, but much remains to be learned. One reason for this gap may be our conceptualization of substance use disorders. The substance dependence criteria in DSM-

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IV are based on the concept of the Alcohol Dependence Syndrome (ADS) (Edwards and Gross, 1976), generalized to drugs in 1981 (World Health Organization, 1981). Dependence was considered to be a combination of physiological and psychological processes leading to increasingly impaired control over substance use even in the face of negative consequences. This syndrome was considered one “axis” of substance problems, with the consequences of heavy use (social, legal, medical problems, hazardous use) considered a different axis of substance use problems.

Contrary to clinical assumptions, alcohol abuse does not necessarily lead to dependence (Hasin et al., 1990; Grant et al., 2001b; Schuckit et al., 2001; Schuckit et al., 2002). Furthermore, not all individuals with alcohol dependence or drug dependence (Grant et al., 2001a; Hasin and Grant, 2004) manifest abuse symptoms. The concepts of DSM-IV substance abuse and dependence are commonly used in clinical work and research studies, but there is debate as to whether abuse and dependence represent two different but related syndromes, or are two degrees of severity of a common syndrome (Hasin and Grant, 2004; Hasin et al., 2005). This is important because if currently used categories do not appropriately characterize the underlying structure of substance use disorders, research may target imprecise entities or processes, and, thus, be less likely to advance an understanding of etiology and effective treatment.

One way to examine the validity of substance use disorders categories is to investigate the factor structure of the diagnostic criteria. Several studies have investigated the factor structure of alcohol use disorders in clinical populations and epidemiological samples (Muthen et al., 1993a; Muthen et al., 1993b; Muthen, 1995; Muthen, 1996; Hasin et al., 1997b; Hasin et al., 1999; Harford and Muthen, 2001). Those studies generally, but not always (Hasin et al., 1994; Feingold and Rounsaville, 1995; Langenbucher et al., 2004; Proudfoot et al., 2006), indicated the presence of two correlated but distinct factors. While not replicating the DSM-IV categories exactly, the first factor is generally characterized by DSM-IV dependence criteria, while the second is generally characterized abuse criteria.

To date, there are no published population-based studies of the structure of cocaine use disorders and only two reports, both from an Australian survey, on the latent structure of cannabis disorders. The first study (Swift et al., 2001) used the full sample to conduct a principal components analysis of dependence criteria, finding that a unidimensional syndrome characterized dependence well. This study did not investigate abuse criteria. The second report (Teesson et al., 2002) used a latent variable approach (Harford and Muthen, 2001) to model DSM-IV cannabis abuse and dependence criteria among 722 respondents who used cannabis. Both a one- and correlated two-factor model fit the data well. On the grounds of parsimony, the one-factor solution was preferred. Data in clinical samples have suggested that a two-factor solution offered a better model fit (Feingold and Rounsaville, 1995; Nelson et al., 1999), although the 1-factor model is sometimes preferred on the basis of parsimony (Feingold and Rounsaville, 1995; Langenbucher et al., 2004).

We used data from a very large, U.S. national sample of adults to examine the latent variable structure of DSM-IV marijuana and cocaine use disorders. Based on the original bi-axial concept and its implementation in DSM-IV, we predicted a similar factor structure of dependence and abuse criteria for cocaine and cannabis, and also predicted that the structure would be similar to the factor structure found previously for alcohol use disorders (Muthen et al., 1993a; Muthen, 1995).

2. Method

Study Design

Data were derived from the 1992 National Longitudinal Alcohol Epidemiologic Survey (NLAES), which consisted of face to face interviews of a nationally representative U.S. sample aged 18 years and older (N=42,862). The NLAES used a complex multistage design (Grant, 1995; Grant and Harford, 1995) that stratified by sociodemographic criteria and oversampled for African-Americans (Grant, 1997; Hasin and Grant, 2002). The voluntary nature of participation was described to the respondent, as well as the careful procedures for protecting confidentiality. Those respondents consenting to participate after receiving this information were interviewed. The overall response rate for the NLAES was 90.0% (Compton et al., 2004).

2.1 Subjects

This study relied on two sub-samples of the NLAES respondents. Analyses of the cannabis abuse and dependence criteria included the 5,780 NLAES respondents with lifetime marijuana use. Analyses of the cocaine abuse and dependence criteria included the 1,585 NLAES respondents reporting lifetime cocaine use. “Lifetime use” was defined as use of these drugs at least 12 times in the subject's lifetime.

2.2 Measures

The Alcohol Use Disorder and Associated Disabilities Interview Schedule (AUDADIS) (Grant et al., 1995) is a structured diagnostic interview designed for trained non-clinician interviewers. The AUDADIS showed excellent psychometric properties in U.S. and international reliability and validity studies of DSM-IV substance dependence (Grant et al., 1995; Chatterji et al., 1997; Hasin et al., 1997a; Hasin et al., 1997b; Canino et al., 1999; Hasin et al., 2000; Grant et al., 2003). To operationalize DSM-IV substance use disorders criteria, the AUDADIS includes detailed questions covering repeated instances of the seven dependence and four abuse criteria. History of treatment related to substance use, including Narcotics Anonymous (NA), detoxification, emergency room admission, and inpatient and outpatient hospitalizations was used as the external criterion variable. Other background variables included respondent's age, categorical measures of gender (male = 1). Dummy variables were created for race/ethnicity (black, non-Hispanic = 1; Hispanic = 1; with other as referent), marital status (previously married = 1; never married = 1; with married as the referent), education (<12 years = 1; > 12 years = 1; with 12 years as the referent), and employment status (employed full time = 1; employed part time = 1; with not employed as referent).

2.3 Analytic Plan

Latent variable modeling techniques were used to determine whether one or more continuous latent variables explained the covariation among set of criteria (i.e., symptom items), regressed on the covariates.

In factor analysis, where the outcomes (factors) are dimensional variables, increasing factor values correspond to increased risk. This approach avoids the problem of threshold choice inherent in dichotomous diagnosis, which can introduce misclassification error. We used a multiple causes and multiple indicators (MIMIC) factor analysis model (Muthen, 1995; Harford and Muthen, 2001), in which one or more latent variables (i.e., substance abuse and dependence) intervene between a set of observed background variables predicting a set of observed response variables (i.e., DSM-IV symptom items). In the MIMIC model, the influence of background variables on the outcome variables (i.e. symptom items) is mediated

by the latent factors. Although this model reflects a different version of mediation than in the conventional sense, it is analogous to conventional mediation models (Muthen, 1995).

As a preliminary step, the 11 criteria were analyzed using exploratory factor analysis (EFA). We used EFA because our previous analytic experience indicated that the DSM-IV categories might not be replicated exactly by our analysis, and showing such divergence had the potential to be important. Factor selection was guided by several indicators, including eigenvalue plots, root mean square residuals (RMSR), chi-square test of fit, and "interpretability". The results of the EFA were used to specify the factor structure in the MIMIC model. The MIMIC model is referred to as EFA within a confirmatory factor analysis (CFA) framework and related to the background and criterion variables. In the present study, background and criterion variables included age, gender, race, ethnicity, marital status, employment status, and history of substance abuse treatment.

The MIMIC model includes three sets of relationships: those between the symptom items and the factors (the measurement model); those between the factors and the covariates (the structural regression equations); and those between the symptom items and the covariates (the direct effects). Direct effects are probit regression coefficients for the binary criteria items. The presence of direct effects implies that there are differences in the factor model based on the covariates (e.g., factor structure is not identical for all population subgroups). It is important to stress, though, that both the reported measurement model and structural equation models are adjusted for the present of direct effects, in the same way that main effects are adjusted for other covariates in more traditional regression models.

The default estimator for analysis was a robust, weighted, least-squares estimator. Fit indices for measurement models included chi square, comparative fit index (CFI), root mean square residuals (RMSR), and root mean square error approximation (RMSEA). Muthén and Muthén (Muthen and Muthen, 1998) suggest the following cutoff values as indicators of good fit: CFI > 0.95; RMSR < .05; RMSEA < 0.06. The analyses were implemented with Mplus (Muthen and Muthen, 1998; Muthen and Muthen, 2004), which takes into account NLAES sampling weights and design effects in all analyses, including parameter as well as standard error estimation and model fit calculations.

3. Results

3.1 Exploratory Factor Analyses

Eigenvalues from the EFA of DSM-IV criteria for marijuana use disorders indicated one large factor (6.9), "dependence" and a smaller factor (0.84), "abuse" with the remaining eigenvalues forming a straight line (0.55; 0.52; 0.45; 0.42; 0.36; 0.30; 0.27; 0.19; 0.17). Both one factor (x^2=258.8, df=41, RMSR=.038) and two-factor solutions (x^2=133.8, df=32, RMSR=0.027) were obtained. The two-factor solution was preferred because it significantly improved the fit over the single factor solution (x^2=125.0, df=9, p<.001). A three-factor solution could not be obtained due to severe error variance.

The proportions of respondents endorsing each criterion and the factor loadings for these solutions, presented in Table 1 are interpreted as abuse and dependence. The abuse factor had large loadings on three DSM-IV abuse criteria: role obligations, hazardous use, and legal problems. The remaining criteria loaded on the dependence factor. Similar to results found previously for alcohol, the two marijuana factors were highly correlated (0.73). "Social problems" and "give up activities in order to use" had similar factor loadings on both the abuse and dependence factors, indicating that they did not discriminate between the factors.

Eigenvalues from the EFA of DSM-IV criteria for cocaine use disorders also indicated one large factor (8.0), "dependence" and a smaller factor (0.71), "abuse", with the remaining eigenvalues forming a straight line (0.51; 0.41; 0.29; 0.28; 0.22; 0.20; 0.15; 0.13; 0.10). Both one-factor (x^2=110.1, df=38, RMSR=.03) and two-factor solutions (x^2=50.8, df=33, RMSR=0.02) were obtained. The two-factor solution was preferred because it significantly improved the fit over the single factor solution (x^2=59.3, df=5, p<.001). The three-factor solution contained negative residual variances indicating over-factoring. The two factors were highly correlated (0.77). The proportions of respondents endorsing each criterion and the factor loadings for these solutions are presented in Table 1 and are interpreted as abuse (column 4) and dependence (column 5). The abuse factor had large loadings on two DSM-IV abuse criteria (role obligations and hazardous use). The factor loadings for the abuse criterion "legal problems" were similar for both factors. The remaining criteria loaded on the dependence factor.

3.2 MIMIC models

The structural regression estimates for each factor with each of the background characteristics is presented in Table 2 separately for marijuana and cocaine use disorders. In MIMIC models, the relationships between the factors and the covariates are described statistically by means of linear regression and are interpreted as partial regression coefficients, similar to those in linear multiple regression. For marijuana, the difference in fit of between the model with five direct effects (x^2=96.4, df=36, CFI=.99, RMSR=0.01) and model without direct effects (x^2=128.1, df=38, CFI=.99, RMSR=0.01), indicated that the addition of direct effects significantly improved the fit (x^2=37.1, df=2, p<.001). In contrast, for cocaine, the difference in fit betwen the model with direct effects (x^2=45.5 df=29, CFI=.99, RMSR=0.01) and the model without direct effects (x^2=47.5, df=30, CFI=.99, RMSR=0.004). was not statistically significant (x^2=2.0, df=1, p=.15)

In the case of marijuana use disorders, the structural regression coefficients for abuse indicated that respondents who were older, black, Hispanic, never married, or had > 12 years education had lower estimates of abuse, while males and respondents with a lifetime history of substance abuse treatment had higher estimates of abuse. For dependence, the structural regression coefficients indicated that respondents who were older, Hispanic, never married, or had > 12 years education had lower estimates of dependence, while respondents with a lifetime history of substance abuse treatment had higher estimates of dependence. Overall, the background variables accounted for a modest amount of variance (19% for abuse, 11% for dependence).

There was a significant and negative direct effect for lifetime treatment related to the abuse criterion for hazardous use (estimate = −0.48, S.E. = 0.08) indicating that with the same value for the abuse factor, respondents with lifetime treatment had a lower probability for endorsing this criterion. There were two direct effects associated with gender. Controlling for factor values, males had a lower probability for role impairment (estimate = −0.26, S.E. = 0.07) and a higher probability for impaired control (estimate = 0.36, S.E. = 0.09). Factor values being the same, older respondents had a higher probability for spent time (estimate = 0.01, S.E. = 0.004), while respondents with < 12 years of education had a lower probability for hazardous use (estimate = −0.26, S.E. = 0.07).

In the case of cocaine use disorders, the structural coefficients for abuse indicated that respondents who were older, had < 12 years of education, and never married had lower estimates of abuse, while males and respondents with a lifetime history of substance abuse treatment had higher estimates of abuse. The structural coefficients for dependence indicated that older respondents and those with > 12 years of education had lower estimates of dependence, while blacks and those with a lifetime history of substance abuse treatment had higher estimates of dependence. Similar to the results in the marijuana use disorders, the

background variables accounted for a modest amount of variance (14% for abuse, 22% for dependence). The presence of direct effects indicates that not all effects of background variables are fully mediated by the latent variables, thus suggesting measurement non-invariance.

There were only two statistically significant direct effects related cocaine criteria. Factor values being the same, males had a lower probability for the withdrawal criterion (estimate = −0.16, S.E. = 0.05), while respondents with a history of lifetime treatment had a higher probability for the dependence criterion “give up activities” (estimate = 0.26, S.E. = 0.06).

4. Discussion

This is the first study to examine the latent structure cannabis and cocaine abuse and dependence criteria in a nationally representative sample. Our study has two major findings. First, similar to findings in alcohol use disorders (Muthen et al., 1993a; Muthen, 1995; Harford and Muthen, 2001), the latent structure of marijuana and cocaine use disorders supports a model with one large factor, which resembles dependence and explains most of the variance, and a smaller factor resembling the DSM-IV category of substance abuse. Second, although substance abuse and dependence constitute independent dimensions, they are highly correlated. The results of our study, in a large and diverse sample, indicate that the factors identified for cocaine use disorders are remarkably similar to those identified for marijuana use disorders. In conjunction with the findings in alcohol use disorders, the results of this study suggest that a 2-factor correlated structure is shared across substance use disorders.

Our findings are important because they suggest that similarities in substance use syndromes are not limited to their phenomenological presentation, but may extend to similarities in latent structures across illicit drugs as well as alcohol. Our analysis is limited to uncovering latent statistical relationships, but the consistency of the results over alcohol, cannabis and cocaine (three substances with considerably different physiological effects) suggests consistency in the biological and/or environmental factors that give rise to dependence and abuse, at least in the United States.

A second finding of our study is that, although abuse and dependence are structured to constitute two independent substance use disorders in DSM-IV, their symptoms do tend to co-occur. Previous work, including the hierarchical diagnostic algorithm of DSM-IV (American Psychiatric Association, 1994), has often assumed that abuse and dependence constitute the same disorder and differ only by degree of severity. Recent work by our group (Hasin and Grant, 2004; Hasin et al., 2005) has shown that abuse does not always co-occur with dependence, and that use of DSM-IV alcohol or drug abuse as a screen can lead to missed diagnoses of dependence. Perhaps the reason for the consistency in finding better model fits for two factors than one, even though the factors are correlated, lies in the presumed nature of the two constructs. Dependence is a condition that leads to increasingly heavy use despite adverse consequences (Edwards and Gross, 1976) that is determined in large part by heritable factors (Kendler et al., 2003a; Kendler et al., 2003b). Abuse mainly represents the consequences of heavy use of alcohol or drugs. These consequences may be determined by external factors such as the availability of a car to drive while intoxicated (hazardous use). Thus, the use engendered by dependence may lead to abuse symptoms and thus give rise to correlated factors, although the causes of the factors may differ.

The results of the present study suggest that this also may be the case in marijuana and cocaine use disorders, and suggest that abuse and dependence are two different disorders. At the same time, the high degree of correlation between the two factors indicate that, when considering lifetime diagnoses, individuals meeting criteria for one of them, are highly likely to meet criteria

for the other. Whether treatment approaches should be different for abuse and dependence is unknown at present.

Finally, we detected the presence of direct effects in the models for both marijuana and cocaine use disorders, suggesting that the expression of the factors is partially modified by the background characteristics of the individuals (e.g., for individuals endorsing the exactly the same symptoms, the severity of marijuana abuse Blacks is lower than “others”, while the opposite is true for males compared to females.). An important direction for future research would be the identification of the genetic determinants that influence the development of these syndromes in different populations, and the sociodemographic characteristics that influence their expression. Clinical syndromes derived from general population studies that are robust across important sociodemographic groups also may constitute excellent candidate phenotypes for future genetic studies.

Our study has several limitations. First, it is limited to marijuana and cannabis, and does not examine whether the same latent structure holds true for other substances such as amphetamines, work that is currently underway by our group. Second, our analyses focus on cross-sectional data, and do not examine whether the described latent structures are stable over time. In particular, our analyses do not examine whether the factor loadings and composition are invariant over treatment. Examination of longitudinal data may help elucidate this question and shed light on aspects of substance use disorders that are affected by different treatment approaches. Third, our analyses used a single dataset. Replication is warranted. Finally, the data are based on self-report. Thus, factors associated with the different social desirability in the endorsement of certain criteria may have biased the estimation of the latent structures.

In conclusion, the latent structure of substance use disorders appears to be best described by two independent but correlated factors. Those factors appear to be generally invariant over substances and sociodemographic groups. A challenge for future research will be the examination of biological and social determinants of those factors and their treatment implications.

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Table 1

Frequency and Factor Loadings for DSM-IV Criteria for Lifetime Marijuana and Cocaine Use[a].

	Marijuana Users (N=5,780)			Cocaine Users (N=1,585)		
	Criterion Frequency	Factor 1 ("Abuse")[b]	Factor 2 ("Dependence")	Criterion Frequency	Factor 1 ("Abuse")[c]	Factor 2 ("Dependence")
DSM-IV Abuse		**Loadings**			**Loadings**	
Role	26	0.84	0.09	34.7	0.91	0.08
Hazard	46.5	0.56	0.22	49.5	0.62	0.20
Legal	5.6	0.49	0.07	7.4	0.29	0.30
Social	24	0.42	0.45	42.6	0.38	0.55
DSM-IV Dependence						
Tolerance	18.7	0.26	0.57	30.6	0.19	0.70
Withdrawal	18	0.18	0.64	47.7	0.30	0.62
More/longer	12.1	0.01	0.82	31.6	0.14	0.78
Impaired control	43.7	0.07	0.64	56.5	0.06	0.74
	9.5	0.51	0.45	24.1	0.39	0.60
Give up activities						
Continued use	4.6	0.23	0.67	15.5	0.36	0.55
Spent time	10.5	0.33	0.61	24.8	0.08	0.87

[a] All analyses based on weighted data.

[b] Fit statistics for the two-factor model of marijuana use disorders: x^2=133.8, df=32, RMSR=0.027

[c] Fit statistics for the two-factor model of cocaine use disorders: x^2=110.1, df=38, RMSEA=.03

Table 2

Estimated effects of background variables on marijuana and cocaine abuse and dependence: Estimates for Latent Variables of Lifetime Marijuana Use:

	MIMIC Model among Lifetime Marijuana Users (N=5,780)				MIMIC Model among Lifetime Cocaine Users (N=1,585)			
	Abuse		Dependence		Abuse		Dependence	
	Est.	S.E.	Est.	S.E.	Est.	S.E.	Est.	S.E.
Age (in years)	−0.01**	.002	−0.02**	.002	−0.01*	.008	−0.01**	.004
Male	0.47**	.065	−0.01	.043	0.14**	.050	0.08	.051
Black	−0.30**	.074	0.02	.061	0.03	.107	0.29**	.090
Hispanic	−0.32**	.109	−0.17*	.081	−0.01	.107	−0.10	.107
< 12 years	0.04	.065	0.01	.051	−0.20*	.100	−0.06	.105
> 12 years	−0.08*	.035	−0.13**	.030	−0.01	.059	−0.16*	.071
Previously married	−0.02	.046	−0.05	.047	0.07	.068	0.11	.069
Never married	−0.11**	.045	−0.08*	.038	−0.14*	.070	−0.04	.082
Employed full	0.01	.039	0.04	.037	0.01	.075	−0.07	.065
Employed part	−0.05	.061	0.02	.048	0.04	.105	−0.03	.107
Lifetime treatment	1.03**	.078	0.73**	.065	0.80**	.068	1.00**	.069
R^2	.19		.11		.14		.22	

Chi square=96.4 (36); CFI=.99; RMSEA=.01.

[a] Chi square=45.5 (29); CFI=.99; RMSEA=.01.

** p < .01.

* p < .05.