A Twin Study of Personality and Illicit Drug Use and Abuse/Dependence

Arpana Agrawal[1], K. C. Jacobson[2], C. A. Prescott[2], and Kenneth S. Kendler[1,2]

[1] *Virginia Institute of Psychiatric and Behavioral Genetics, Virginia Commonwealth University, Depts. Of Human Genetics and Psychiatry, Richmond, USA*

[2] *Virginia Institute of Psychiatric and Behavioral Genetics, Virginia Commonwealth University, Dept of Psychiatry, Richmond, USA*

Although personality measures such as neuroticism (N), extraversion (E) and novelty-seeking (NS) are associated with the use and abuse/dependence of illicit drugs, little is known about the degree to which these associations are due to genetic or environmental factors. The goal of this analysis was to estimate the extent of genetic and environmental overlap between three dimensions of personality (N, E and NS) and illicit psychoactive substance use and abuse/dependence. Using data from adult male and female twins from the Mid-Atlantic Twin Registry, we used the structural equation modeling package Mx to perform bivariate Cholesky decompositions for personality measures of N, E and NS, individually with cannabis, cocaine, sedatives, stimulants and hallucinogens. This was done separately for use and for a polychotomous diagnosis of abuse and/or dependence. Sex differences were tested. The phenotypic relationship between personality and use and abuse/dependence of illicit drugs were moderate and most of the covariance was explained by genetic factors. Sexes could be equated for N and E but not for NS. For NS, use and abuse/dependence of illicit drugs showed greater phenotypic and genetic overlap in males than females. Of the personality measures, NS and illicit drug use and abuse/dependence were most closely related. NS was most closely related to cannabis use while N showed significant genetic overlap with sedative use. NS in males appears to be a good indicator of risk for cannabis use. This result may be useful for candidate gene studies.

Personality is defined as a stable and enduring disposition that shapes human behavior. Personality traits determine an individual's perception of self and the surrounding environment (American Psychiatric Association, 1994). The trait theory defines personality traits as "dimensions of individual differences in tendencies to show consistent patterns of thoughts, feelings, and actions" (McCrae & Costa, 1990). Dimensions of personality include measures like extraversion (E), neuroticism (N) and novelty-seeking (NS).

Different methods have evolved to assess personality. In an attempt to consolidate the diverse approaches to personality assessment, Tupes and Christal proposed the Five Factor Model (Goldberg, 1981; Tupes & Christal, 1961). N and E are consistently measured by the different typologies adopted to explain dimensions of personality. E and N correspond to Factor I and IV respectively, in the "Big Five". NS is also assessed in some form by various personality scales. For example, the Tridimensional Personality Questionnaire directly measures NS (Cloninger, 1987). Aspects of NS also correlate with the NEO-PI constructs of E and Conscientiousness (inverse of NS) (Costa & McCrae, 1985). Sensation-seeking and NS are correlated between .58 and .66 (Zuckerman, 1994). Other personality scales include factors like impulse-disinhibition, risk-taking, diversive curiosity, monotony avoidance and impulsivity (Zuckerman, 1994) which are related to NS.

Personality may also influence maladaptive behavior. Personality traits are proposed as mediating and moderating risk factors for several Axis I disorders. For example, substantial evidence suggests that N plays an important role in the development of Mood and Anxiety Disorders (Fanous et al., 2002; Jang et al., 2000; Stein et al., 2001).

Illicit drugs may be defined in two ways: one category includes drugs that are illegal (e.g., marijuana and cocaine) while the other category reflects the inappropriate use of certain prescription drugs. This second category refers to misuse of prescription sedatives or stimulants. Use of illicit drugs from either category involves some form of defiance of legal or social sanction. This deviancy reflects risk-taking behavior and may stem from underlying psychopathology. Personality dimensions may influence an individual's liability to experiment and regularly use an illicit drug or the probability that use would

Address for correspondence: Arpana Agrawal, Virginia Commonwealth University, Virginia Institute for Psychiatric and Behavioral Genetics, Department of Human Genetics, Box# 980003 Suite 1-154, Richmond, VA 23298-0003, USA. Email: s4aagraw@vcu.edu

https://doi.org/10.1375/twin.7.1.72 Published online by Cambridge University Press

lead to subsequent abuse/dependence. Sensation-seeking, which measures an individual's desire for varied and novel experiences, is an important initial risk factor for drug use (Zuckerman, 1983; Zuckerman, 1987a; Zuckerman, 1987b).

Several clinical studies support the relationship between elevated NS and use of marijuana, cocaine and ecstasy (Dughiero et al., 2001; Eisenman et al., 1980; Fergusson & Horwood, 2000; Laviola et al., 1999). Also, high E scores are associated with more frequent use of illicit drugs when transitioning from adolescence to adulthood (Guy et al., 1994; Spotts & Shontz, 1984; Spotts & Shontz, 1991). Additionally, high N may significantly influence the use of alcohol, cocaine and opiates (Ball et al., 1998). While these studies can quantify the association between personality and illicit drug use or abuse/dependence, they provide us only limited insight into the mechanisms of the association.

A few genetically informative analyses have examined the nature of the overlap between genetic factors for personality and use of alcohol and nicotine. Jang et al. report high phenotypic and genetic correlations between measures like stimulus-seeking, callousness and conduct-problems and alcohol misuse (Jang et al., 2000). Grove et al. (1990), using twin pairs reared apart, show substantial genetic overlap between drug use and items measuring antisocial personality. Slutske et al. (2002) show a strong genetic commonality between behavioral undercontrol and alcohol dependence. Krueger et al. (2002) report that a single common externalizing factor that is mostly explained by genetic factors contributes to the comorbidity of antisocial behavior, personality and substance dependence. Furthermore, Heath et al. (1995) report a significant phenotypic but not genetic association between smoking and NS, E, social conformity and conservatism. Recently, Mustanski et al. (2003) showed that common genetic factors may be responsible for the relationship between alcohol consumption and an excitement-seeking personality construct. While these genetic studies add to the growing body of evidence for an association between facets of personality and licit drugs (ethanol and nicotine), they do not address the association of personality and illicit drug use and abuse/dependence. One genetically informative study studied the relationship between marijuana use and several aspects of risk-taking and sensation-seeking (e.g., sexual promiscuity, seat-belt usage) and suggested that while there was some genetic overlap between risk-taking and marijuana use, a substantial proportion of the covariation was explained by familial and individual-specific environmental factors (Miles et al., 2001).

The present study has the following goals: 1) To assess the extent of familial and environmental overlap between use of illicit drugs (cannabis, cocaine, sedatives, stimulants and hallucinogens) and three measures of personality (N, E and NS) 2) To examine a similar relationship between personality and abuse/dependence of cannabis, cocaine, sedatives and other illicit drugs. 3) To assess for potential sex differences in the relationship between each personality measure and illicit drug use and abuse/dependence.

Subjects and Method

Subjects

Subjects for this analysis are part of a population-based twin study of psychiatric disorders and risk factors. The data for illicit drug use, abuse/dependence and personality come from 1943 female and 2632 male same-sex twins that are part of the most current wave (pending completion of a new wave of male-male data) of interviews available in the Virginia Twin Registry. Twin pairs were ascertained through a systematic screening of birth records in the Commonwealth of Virginia. All interviewers had at least a Master's degree in social work or in another mental health-related field or a Bachelor's degree in a related area with 2 years of clinical experience. There was an initial training period, which was regularly followed up by review sessions. As approved by the institutional review board of Virginia Commonwealth University, prior to interviews, subjects were informed about the aims of the study and informed consent was obtained. Zygosity was initially determined through standard questions and photographs. A subset of 227 twin pairs were genotyped using eight or more highly polymorphic markers and this data along with information regarding height, weight and history of blood tests as well as data from six standard zygosity questions was used to develop an algorithm for a Fisher discriminant function analysis. The discriminant function was used to assign zygosity to our twin pairs. Further details are available elsewhere (Kendler et al., 2000; Kendler et al., 2003).

Measures

Data for this analysis is derived from the fourth wave of interviews with the females and the second wave of interviews with the males. Lifetime use of cannabis, cocaine, sedatives, stimulants and hallucinogens was assessed individually as a binary response to a question regarding lifetime drug use. For the drugs that could be obtained legally (e.g., sedatives), use was assessed only if drug use occurred either (a) without a prescription or (b) in greater amounts/more often than prescribed or (c) for uses other than those prescribed for.

Drug abuse/dependence was coded as a three level variable (0 = neither abuse nor dependence, 1 = abuse only, 2 = abuse and dependence). Abuse and dependence were diagnosed using an adaptation of the Structural Clinical Interview for DSM-III-R Diagnosis (SCID) interview (Spitzer et al., 1987).

Our sample consisted of 1943 female and 2632 male twins from same-sex pairs. The mean age at the time of the interview was 35.5 years (range 20–58

https://doi.org/10.1375/twin.7.1.72 Published online by Cambridge University Press

years) for the males and 35.8 years (range 21–62 years) for the females. The mean of years of education reported by the twins was 13.6 years and 14.3 years in the males and females, respectively. Figure 1 (A, B) present the rates of prevalence of use and abuse/dependence of each of the illicit psychoactive substances in our data.

N and E were assessed using items from the short-form of the Eysenck Personality Questionnaire (EPQ; Eysenck et al., 1985). N and E are measured by 12 and 8 items, respectively. N is defined as a predisposition to negative affect or emotionality. An example of an item assessing N is "Are you the type of person whose mood often goes up and down?" In contrast, positive affect and high sociability characterize high scores of E. An example of an item assessing E is "Are you the type of person who enjoys meeting people?" The scale for NS was constructed based on an adaptation of Cloninger's Tridimensional Personality Questionnaire (Cloninger, 1987), consisted of 23 items and included questions like "Are you the type of person who often tries new things for the fun or thrills, even if most people think it is a waste of time?" The response categories were binary for all items. Total scores on the E, N and NS scales ranged from 0–8, 0–12 and 0–23, respectively. Based on the range of E scores, N and NS scores were also polychotomized to range between 0–8. This also reduced the skewness of the distribution of N scores. Furthermore, confirmatory factor analysis was performed on the tetrachoric correlation matrix of the novelty-seeking items, using Mplus (Muthen & Muthen, 1998). Logistic regressions performed on NS

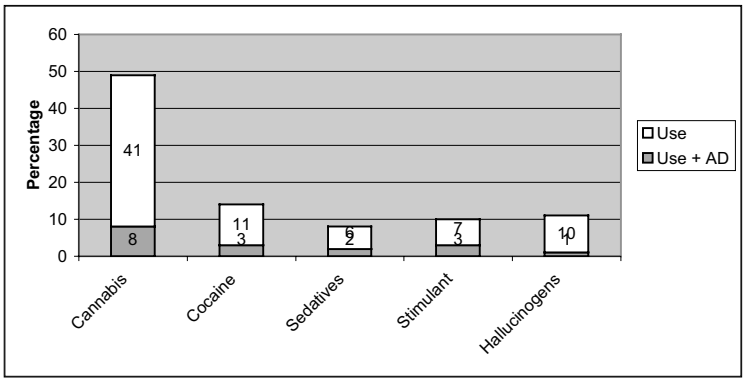

Figure 1A

Prevalence of Illicit drug use and illicit drug use followed by subsequent abuse/dependence (AD) in *N* = 1943 female same sex MZ and DZ twins.

Note: Users without abuse/dependence are shown as a percentage of *N* = 1943 females. The gray bars show the percentage of females with use and abuse/dependence.

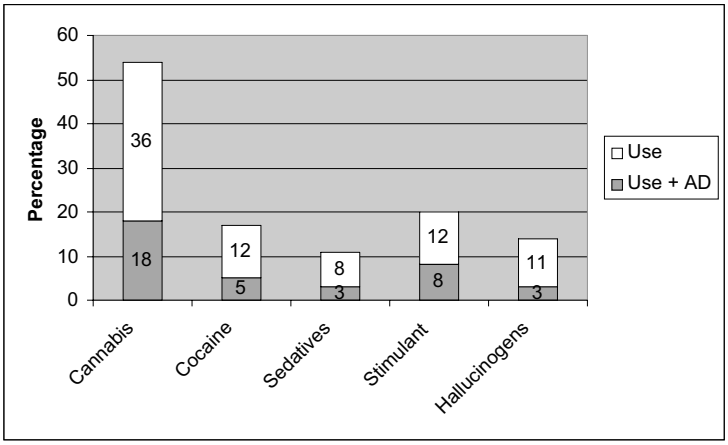

Figure 1B

Prevalence of Illicit drug use followed by subsequent abuse/dependence (AD) in N=2632 male same-sex MZ and DZ twins.

Note: Users without abuse/dependence are shown as a percentage of *N* = 2632 males. The gray bars show the percentage of males with use and abuse/dependence.

https://doi.org/10.1375/twin.7.1.72 Published online by Cambridge University Press

subfactors was done using PROC LOGISTIC in SAS (SAS Institute, 1999).

Twin Modeling

Based on the classical twin model, we allowed for three sources of variance that explained individual differences: additive genetic factors (A), shared environmental factors (C) and individual-specific environmental factors (E). We fit bivariate Cholesky models, individually, for each drug with each personality measure. The bivariate Cholesky allows for two sets of genetic, shared and unique/individual-specific environmental factors. The first factor of A, C and E influence both novelty-seeking (upstream variable) as well as cannabis use (downstream variable) and the second factor of A, C and E influence cannabis use alone. The aim of the Cholesky was to determine the extent to which personality measures explained the phenotype of illicit drug use and abuse/dependence and to calculate the magnitude of risk factors specific to illicit drug use or abuse/dependence. Consequently, the upstream variables in each Cholesky were the individual personality measures (N, E and NS) and the downstream variable was illicit drug use or abuse/dependence. A total of 15 bivariate models (5 illicit drugs × 3 personality measures) were fit, separately in males and females, for illicit drug use. Similarly, we fit 15 bivariate models for abuse/dependence. Sex differences were examined by equating all parameters, except thresholds, across sexes. All model-fitting was performed using the structural equation modeling software Mx (Neale, 1990). Additional details regarding the Cholesky are available elsewhere (Neale & Cardon, 1992).

Results

Twin Analyses

Table 1 presents the parameter estimates for the bivariate Cholesky models assessing the relationship between NS and illicit drug use and abuse/dependence. Table 2 presents similar results for the bivariate models examining the relationship between E and N and illicit drug use and abuse/dependence.

Illicit Drug Use and Personality

We noted significant gender differences in the relationship between NS and illicit drug use. Parameters could not be equated across sexes and so results are presented separately. Additive genetic influences explain 17% and 38% of the individual differences in NS for males and females, respectively. The remainder of the variance was explained by individual-specific environmental influences with no evidence for shared environmental factors. Accordingly, the bivariate models examining the relationship between personality and illicit drug use were AE-ACE models where shared environmental influences on the upstream personality variables were constrained to zero without a significant deterioration of fit. This means that while shared environmental influences play a role in the total variance in illicit drug use, their contribution to the dimensions of personality was negligible.

In the males, the total phenotypic covariance between NS and illicit drug use was modest and ranged from .23–.29. Genetic factors explained 54% to 70% of this total phenotypic relationship. The genetic correlations between NS and illicit drug use ranged from 0.46 for sedatives to 0.96 for cannabis. With the exception of the high genetic correlation with cannabis, the remaining illicit drugs presented with similar correlations. Individual-specific environmental correlations were consistently low and ranged from .14 to .28. Overall, NS and cannabis use shared the greatest proportion of familial and especially, genetic factors.

The phenotypic association between illicit drugs and NS was lower in the females (.11 to .15) than the males. Despite the difference in total covariance, the majority of the phenotypic association was accounted for by genetic factors. The genetic influences explained a large percentage of the covariance (71% to 94%) for hallucinogens and stimulants and a moderate proportion of the covariance for sedatives (31%). The high genetic correlations between NS and illicit drug use observed in the males were not observed in the females. In contrast to the findings in the males, genetic correlations between NS and illicit drug use in females ranged between .09 for sedatives and .32 for stimulants. The correlations between individual-specific environmental influences were consistently low (.04 to .17).

Genetic factors explained 38% of the total variance for E. There was no evidence for shared environmental factors. Furthermore, sexes could be equated for all the bivariate analyses. The total covariance between E and illicit drug use ranged between .09 and .16. Once again, genetic influences accounted for the greatest proportion of the total phenotypic relationship. Genetic correlations between E and illicit drug use were moderate (.17 to .42) with cannabis use showing the greatest overlap of genetic factors with E. However, the genetic correlations were substantially lower than those observed for NS and illicit drug use in males. Individual-specific environmental factors were correlated between .02 and .19.

The relationship between N and illicit drug use was an interesting contrast to the findings for E and NS. Genetic factors accounted for 32% of the total variance in N and 68% of the variance was explained by individual-specific environmental factors. No sex differences were observed. The total covariance between the two phenotypes ranged from .11 for cannabis use to .17 for sedative use. Genetic factors were responsible for a large proportion of this covariance for cannabis and sedative use (82%) and accounted for a moderate proportion of the covariance for use of cocaine, stimulants and hallucinogens (50% to 62%).

Genetic correlations between illicit drug use and N ranged from .00 to .31. Antithetic to the substantial

https://doi.org/10.1375/twin.7.1.72 Published online by Cambridge University Press

Table 1

Standardized Variance Component Estimates for Bivariate Models for Novelty-seeking (NS) and Illicit Drug Use and Abuse/Dependence, Separately in Males and Females

Drug	Phenotype		A	C	E	Ra	Re	Total Covariance	%A	%E
Novelty Seeking: Males										
Cannabis	Use	P	0.17	—	0.83	0.96	0.14	0.28	65	25
		D	0.23	0.45	0.32					
	AD	P	0.17	—	0.83	0.57	0.16	0.28	71	29
		D	0.76	—	0.24					
Cocaine	Use	P	0.17	—	0.83	0.62	0.18	0.29	69	31
		D	0.59	0.14	0.28					
	AD	P	0.17	—	0.83	0.56	0.12	0.25	76	24
		D	0.69	—	0.31					
Sedatives	Use	P	0.17	—	0.83	0.46	0.14	0.23	70	30
		D	0.68	0.00	0.32					
	AD	P	0.16	—	0.84	0.53	0.07	0.20	80	20
		D	0.59	—	0.41					
Stimulants	Use	P	0.17	—	0.83	0.47	0.24	0.26	54	46
		D	0.50	0.20	0.30					
	AD	P	0.16	—	0.83	0.68	0.03	0.25	91	9
		D	0.68	—	0.32					
Hallucinogens	Use	P	0.17	—	0.83	0.59	0.21	0.28	75	25
		D	0.65	0.21	0.14					
	AD	P	0.16	—	0.84	0.36	0.28	0.28	43	57
		D	0.64	—	0.36					
Novelty Seeking: Females										
Cannabis	Use	P	0.38	—	0.61	0.19	0.05	0.15	94	6
		D	0.46	0.29	0.25					
	AD	P	0.39	—	0.61	0.22	0.02	0.12	92	8
		D	0.69	—	0.31					
Cocaine	Use	P	0.36	—	0.61	0.30	0.08	0.14	71	29
		D	0.28	0.43	0.29					
	AD	P	0.39	—	0.61	0.06	0.02	0.04	75	25
		D	0.62	—	0.38					
Sedatives	Use	P	0.39	—	0.61	0.09	0.17	0.13	31	69
		D	0.49	0.09	0.42					
	AD	P	0.39	—	0.61	0.12	0.02	0.06	83	17
		D	0.54	—	0.46					
Stimulants	Use	P	0.39	—	0.61	0.32	0.04	0.11	82	18
		D	0.21	0.34	0.44					
	AD	P	0.39	—	0.61	0.14	0.02	0.08	88	12
		D	0.68	—	0.32					
Hallucinogens	Use	P	0.39	—	0.61	0.24	0.08	0.14	75	25
		D	0.48	0.26	0.26					
	AD	P	0.39	—	0.61	0.00	0.02	0.01	0	100
		D	0.62	—	0.28					

Note: P = estimates for personality (NS), D = Illicit drug use or abuse/dependence, AD = Abuse/Dependence, A = additive genetic influence, C = shared environmental influence, E = unique environmental influence, Ra = genetic correlation across phenotypes, Rc = shared environmental correlation across phenotypes, Re = unique environmental correlation across phenotypes.

The shared environmental factors (C) were constrained to zero for abuse/dependence and this did not result in a serious deterioration of fit. For the bivariate Cholesky between drug use and personality the shared environmental influence on personality (but not on drug use) was also set to zero with no deterioration in fit. The estimates presented for abuse/dependence (AD) are derived from and AE model. Sex differences were noted for all bivariate models for NS. Results are presented for both sexes.

https://doi.org/10.1375/twin.7.1.72 Published online by Cambridge University Press

Table 2

Parameter Estimates for Bivariate Models for Illicit Drug Use and Abuse/Dependence with Extraversion (E) and Neuroticism (N) in a Sex-equal Model

Drug	Phenotype		A	C	E	Ra	Re	Total	%A Covariance	%E
Extraversion										
Cannabis	Use	P	0.38	—	0.62	0.42	0.19	0.16	94	6
		D	0.35	0.37	0.28					
	AD	P	0.39	—	0.61	0.16	0.02	0.09	89	11
		D	0.73	—	0.27					
Cocaine	Use	P	0.39	—	0.62	0.36	0.02	0.16	94	6
		D	0.45	0.26	0.29					
	AD	P	0.39	—	0.61	0.23	0.02	0.12	91	9
		D	0.65	—	0.35					
Sedatives	Use	P	0.39	—	0.61	0.19	0.02	0.10	90	10
		D	0.62	0.04	0.34					
	AD	P	0.38	—	0.62	0.00	0.16	0.09	0	100
		D	0.46	—	0.54					
Stimulants	Use	P	0.38	—	0.62	0.17	0.08	0.10	60	40
		D	0.32	0.33	0.35					
	AD	P	0.38	—	0.62	0.11	0.24	0.17	29	71
		D	0.64	—	0.38					
Hallucinogens	Use	P	0.38	—	0.62	0.20	0.02	0.09	89	11
		D	0.45	0.35	0.20					
	AD	P	0.38	—	0.62	0.08	0.11	0.09	44	56
		D	0.64	—	0.35					
Neuroticism										
Cannabis	Use	P	0.32	—	0.66	0.18	0.05	0.11	82	18
		D	0.34	0.39	0.27					
	AD	P	0.34	—	0.66	0.19	0.16	0.16	56	44
		D	0.73	—	0.27					
Cocaine	Use	P	0.34	—	0.66	0.18	0.11	0.12	58	42
		D	0.50	0.21	0.29					
	AD	P	0.34	—	0.66	0.00	0.45	0.22	0	100
		D	0.64	—	0.36					
Sedatives	Use	P	0.34	—	0.66	0.31	0.07	0.17	82	18
		D	0.60	0.06	0.34					
	AD	P	0.34	—	0.66	0.24	0.14	0.18	56	44
		D	0.44	—	0.56					
Stimulants	Use	P	0.32	—	0.66	0.21	0.17	0.16	0	50
		D	0.36	0.30	0.34					
	AD	P	0.34	—	0.66	0.23	0.15	0.18	56	44
		D	0.58	—	0.43					
Hallucinogens	Use	P	0.33	—	0.66	0.13	0.13	0.13	62	31
		D	0.50	0.31	0.19					
	AD	P	0.34	—	0.66	0.28	0.14	0.20	65	35
		D	0.63	—	0.37					

Note: P = estimates for personality (E, N), D = Illicit drug use or abuse/dependence, AD = Abuse/Dependence, A = additive genetic influence, C = shared environmental influence, E = unique environmental influence, Ra = genetic correlation across phenotypes, Rc = shared environmental correlation across phenotypes, Re = unique environmental correlation across phenotypes.

The shared environmental factors (C) were constrained to zero for abuse/dependence and this did not result in a serious deterioration of fit. For the bivariate Cholesky between drug use and personality the shared environmental influence on personality (but not on drug use) was also set to zero with no deterioration in fit. The estimates presented for abuse/dependence (AD) are derived from and AE model. No sex differences were noted. Parameter estimates are presented from a common model for males and females.

https://doi.org/10.1375/twin.7.1.72 Published online by Cambridge University Press

genetic correlation observed between cannabis use and NS, N and cannabis use showed a modest genetic correlation of .18. Stimulant use and N showed no genetic overlap. N and sedative use shared the greatest proportion of common genes. The individual-specific environmental factors were weakly correlated (.05 to .17).

Illicit Drug Abuse/Dependence and Personality

For abuse/dependence, the shared environmental component was constrained to zero without a significant deterioration of fit and therefore, only AE models are presented for the Cholesky models examining the relationship between personality measures and illicit drug abuse/dependence. Once again, while sexes could be equated, quantitatively, for N and E, they could not be constrained to be equal for NS.

The total covariance between NS and illicit drug abuse/dependence was similar in magnitude to the covariance obtained for illicit drug use. Genetic factors accounted for 43 to 91% of the total covariance. The genetic correlations between NS and illicit drug abuse/dependence in males were uniform across drug categories and ranged between .36 and .68. Similarly, the individual-specific environmental factors correlated between .03 and .28 across drugs with the greatest correlation being with hallucinogens abuse/dependence.

The relationship between NS and illicit drug abuse/dependence was weaker in the females than in the males. The total covariance that ranged from .01 to .12 was largely explained by genetic factors (73% to 92%) for all drugs, except hallucinogens where the phenotypic relationship was completely explained by individual-specific environmental factors. With the exception of cannabis abuse/dependence that presented with a genetic correlation of .22, the genetic correlations ranged between .00 to .14. The individual-specific environmental correlations were low (.02).

E was weakly related to illicit drug abuse/dependence. The total covariance was similar across drugs and ranged from .09 to .17. With the exception of sedatives, genetic factors explained between 29% to 91% of the total covariance. The genetic correlation between E and sedative abuse/dependence was 0.00. For the remaining drugs, genetic correlations ranged between .08 to .23. Individual-specific environmental factors were poorly correlated across the phenotypes.

The total covariance between N and illicit drug abuse/dependence was fairly uniform across drugs (.16 to .22) and genetic factors accounted for 56% to 65% of the total covariance, with the exception of cocaine abuse/dependence where all the covariance was determined by individual-specific environmental influences. The genetic correlations between N and illicit drug abuse/dependence were between .19 and .28, with the exception of cocaine that did not share any genetic influences with N but presented with an individual-specific correlation of .45. Other drugs showed individual-specific correlations between .14 and .16.

Discussion

There is an extensive body of literature that posits a strong correlation between dimensions of personality and illicit drug use and abuse/dependence (Ball et al., 1998; Dughiero et al., 2001; Eisenman et al., 1980; Fergusson & Horwood, 2000; Laviola et al., 1999; Spotts & Shontz, 1984; Spotts & Shontz, 1991). Some genetically informative studies propose a genetic commonality between personality and licit drugs like alcohol and nicotine. Our goal was to examine the genetic relationship between three measures of personality (NS, N and E) and use and subsequent abuse/dependence of various illicit drugs.

Measures of personality such as N, E and NS were moderately heritable. Our estimates of heritability were similar to those observed in other studies, except for the lowered heritability of NS in males (Loehlin et al., 1998).

We find a moderate phenotypic relationship between dimensions of personality and illicit drug use and abuse/dependence, the strongest association being between illicit drugs and NS in males. This is consistent with the findings of numerous studies. A study of a New Zealand birth cohort of 16-year-olds showed that a significant proportion of the common vulnerability to use alcohol, nicotine or cannabis was explained by NS (Lynskey et al., 1998). Another study of 278 college undergraduates showed greater reported marijuana use in individuals with high NS (Eisenman et al., 1980). We note that overlapping genetic factors comprise a large part of this association. Furthermore, we only detect this strong genetic correlation in males. There is some evidence for the sex-specific nature of the NS construct (Brandstrom et al., 2001). Cloninger et al. (1988) also note that high NS is a predominantly "male" feature. However, a genetic study of alcohol dependence and NS does not support this apparent sex difference (Heath et al., 1997). Our findings suggest that in males, genetic factors for NS are excellent markers for the liability for cannabis use; this is not true of females.

The implications of this finding are two-fold. Behaviorally, this implies that even though cannabis is considered a relatively "innocuous" illicit drug, NS indexes it very well. This could be due to its ease of availability when compared to other illicit drugs. There is also some evidence that NS plays an important role in transitioning from the use of legal to illicit drugs (Golub & Johnson, 2001). This leap from alcohol and nicotine to cannabis relates to a transition from licit to illicit drugs and may be due to a strong genetic overlap between cannabis use and NS. Second, this finding could be utilized in the formulation of molecular studies that aim to isolate candidate genes for the liability to cannabis use. If NS in males is a risk factor for cannabis use, then the genes implicated in NS may also be involved in cannabis use.

The gender differences in the relationship between NS and illicit drug use and abuse/dependence pose an

https://doi.org/10.1375/twin.7.1.72 Published online by Cambridge University Press

interesting question: is the sex difference an artifact of the manner in which males and females interpret the NS construct or are there true differences in the magnitude of genetic influence across males and females? Our exploration of the NS construct suggests that there is a certain level of complexity within the construct itself. However, preliminary analyses verified that the gender differences we observed in the bivariate analyses are probably not due to differences in the construct but are due to differences in magnitude of genetic and environmental factors influencing NS and illicit drug use across sexes.

This strong genetic relationship was true only of NS and not of E or N. We did find sex-independent correlations between genetic factors influencing E and illicit drug use. Although genetic correlations were observed for abuse/dependence of all illicit drugs except sedatives, they were substantially lower than the correlations for use, suggesting a more robust genetic overlap of E with the primary stage of illicit drug use versus the later stage of abuse/dependence. The highest phenotypic relationship was observed between E and cannabis use as well as cocaine use. This finding is well supported by the several other findings in epidemiological samples (Ball et al., 1998; Spotts & Shontz, 1984; Spotts & Shontz, 1991). For example, Guy et al. (1994) used longitudinal data to show the significant role of E in shaping adolescent drug use. Furthermore, N and E were reported to influence subjective mood ratings by smokers of herbal cigarettes containing delta-9-tetrahydrocannabinol (Ashton et al., 1981). Cannabis and cocaine use also showed the greatest genetic overlap with E although the correlations were smaller than those observed for NS.

Our findings with N were markedly different from those with NS and E. A significant overlap of familial factors was seen for N and sedative use. N shares a common vulnerability with Axis I Mood and Anxiety disorders (Duberstein et al., 2001; Fanous et al., 2002; Kendler et al., 2002; Mulder, 2002; Petersen et al., 2001; Oldehinkel et al., 2001; Van et al., 2001). Consequently, a self-medication hypothesis may be a possible explanation for the relationship between N and sedatives. Supporting our outcome, Ashton and Golding (1989) report a higher prevalence of tranquilizer and sedative use in individuals with high N scores. Additionally, our study suggests that a substantial proportion of this phenotypic relationship is driven by common genetic factors.

In conclusion, while our current results support the findings from the epidemiological literature, they also provide an essential elucidation of the nature of the relationship between personality measures and illicit drugs. While genetically informative designs have been employed to study the association of N, E and NS with alcohol and nicotine, they have rarely addressed the issue with illicit drug use or abuse/dependence. Our study not only examines the phenotypic relationship between several categories of illicit drugs, their use and abuse/dependence and personality but also tests the extent to which genetic and environmental factors play a role in this association. According to our analyses, a substantial proportion of the overlap between measures of personality and illicit drug habits is explained by genetic factors. The specificity in the two traits arises from individual-specific environmental influences that are poorly correlated across phenotypes.

Limitations

The results of this study may be viewed with the following limitations in mind:

1. The present sample consists of Caucasian twin pairs, born between 1934 and 1974 in Virginia. Similar results may not be observed in other ethnicities or age groups.
2. These results are dependent on the validity of retrospective report. There may be some recall bias or telescoping when reporting use of illicit drugs and symptoms of abuse/dependence of illicit drugs. While we only have data on the illicit drugs from one wave of interviews, short-term test-retest reliability measures (N = 172 twin pairs measured after 4 weeks of primary interview) are available on a subset of the twin pairs. Drug use was assessed with very high test-retest reliability (r = .98 for cannabis and r > .90 for OID). Abuse/dependence was diagnosed with fair reliability with intra-class correlations r > .80. Additionally, we observed some attrition for the personality measures which were measured using a self-report questionnaire. However, this attrition does not significantly bias our findings (Jacobson et al., 2000).
3. We did not use data from the DZ opposite-sex twin pairs for this analysis. Sex differences were tested quantitatively, by equating parameters across sexes. There is some evidence that parameter estimates in a bivariate sex-limitation Cholesky model are biased by the ordering of the variables (Neale, Roysamb, & Jacobson, 2003).
4. Abuse/dependence was modeled independent of use. Although we are aware of the conditional and contingent nature of familial and environmental factors that influence the downstream variable, we allowed for independent assessment of each stage. It is possible that some of the genetic overlap observed between illicit drug abuse/dependence and personality may be captured by genetic factors that are common to illicit drug use and abuse/dependence. Prescott et al. showed that while E predicts alcohol problems, N predicts alcohol dependence among individuals with alcohol problems (Prescott et al., 1997). While there are methods to examine use and abuse/dependence in a contingent model, the parameterization of such models with covariates (e.g., personality) is complex and the estimation of these models may be unstable.

https://doi.org/10.1375/twin.7.1.72 Published online by Cambridge University Press

Acknowledgments

We thank Patsy Waring, Sarah Woltz, Frank Burns, Lisa Halberstadt, and Barbara Brooke for supervision of data collection, and Indrani Ray, Steve Aggen, and Cheryl Smith for assistance with data management.

References

American Psychiatric Association (1994). *Diagnostic and statistical manual of mental disorders (4th ed.)*. Washington, DC: American Psychiatric Association.

Ashton, H., Golding, J., Marsh, V. R., Millman, J. E., & Thompson, J. W. (1981). The seed and the soil: Effect of dosage, personality and starting state on the response to delta 9 tetrahydrocannabinol in man. *British Journal of Clinical Pharmacology, 12*(5), 705–720.

Ashton, H., & Golding, J. F. (1989). Tranquillisers: Prevalence, predictors and possible consequences. Data from a large United Kingdom survey. *British Journal of Addiction, 84*(5), 541–546.

Ball, S. A., Kranzler, H. R., Tennen, H., Poling, J. C., & Rounsaville, B. J. (1998). Personality disorder and dimension differences between type A and type B substance abusers. *Journal of Personality Disorders, 12*(1), 1–12.

Brandstrom, S., Richter, J., & Przybeck, T. (2001). Distributions by age and sex of the dimensions of temperament and character inventory in a cross-cultural perspective among Sweden, Germany, and the USA. *Psychological Report*, *89*(3), 747–758.

Cloninger, C. R. (1987). A systematic method for clinical description and classification of personality variants. A proposal. *Archives of General Psychiatry, 44*(6), 573–588.

Cloninger, C. R., Sigvardsson, S., & Bohman, M. (1988). Childhood personality predicts alcohol abuse in young adults. *Alcoholism Clinical and Experimental Research*, *12*(4), 494–505.

Costa, P. T., & McCrae, R. R. (1985). *The NEO Personality Inventory Manual*. Odessa, FL: Psychological Assessment Resources.

Duberstein, P. R., Conner, K. R., Conwell, Y., & Cox, C. (2001). Personality correlates of hopelessness in depressed inpatients 50 years of age and older. *Journal of Personality Assessment*, *77*(2), 380–390.

Dughiero, G., Schifano, F., & Forza, G. (2001). Personality dimensions and psychopathological profiles of Ecstasy users. *Human Psychopharmacology, 16*(8), 635–639.

Eisenman, R., Grossman, J. C., & Goldstein, R. (1980). Undergraduate marijuana use as related to internal sensation novelty seeking and openness to experience. *Journal of Clinical Psychology, 36*(4), 1013–1019.

Eysenck, S. B. J., Eysenck, H. J., & Barrett, P. (1985). A revised version of the psychoticism scale. *Personality and Individual Differences, 6*, 21–29.

Fanous, A., Gardner, C. O., Prescott, C. A., Cancro, R., & Kendler, K. S. (2002). Neuroticism, major depression and gender: A population-based twin study. *Psychological Medicine, 32*(4), 719–728.

Fergusson, D. M., & Horwood, L. J. (2000). Cannabis use and dependence in a New Zealand birth cohort. *N.Z. Medical Journal, 113*(1109), 156–158.

Goldberg, L. R. (1981). Language and individual differences: The search for universals in personality lexicons. In L.Wheeler (Ed.), *Review of personality and social psychology* (pp. 141–165). Beverly Hills, CA: Sage.

Golub, A., & Johnson, B. D. (2001). Variation in youthful risks of progression from alcohol and tobacco to marijuana and to hard drugs across generations. *American Journal of Public Health, 91*(2), 225–232.

Grove, W. M., Eckert, E. D., Heston, L., Bouchard, T. J., Jr., Segal, N., & Lykken, D. T. (1990). Heritability of substance abuse and antisocial behavior: A study of monozygotic twins reared apart. *Biological Psychiatry, 27*(12), 1293–1304.

Guy, S. M., Smith, G. M., & Bentler, P. M. (1994). Consequences of adolescent drug use and personality factors on adult drug use. *Journal of Drug Education, 24*(2), 109–132.

Heath, A. C., Bucholz, K. K., Madden, P. A., Dinwiddie, S. H., Slutske, W. S., Bierut, L. J., et al. (1997). Genetic and environmental contributions to alcohol dependence risk in a national twin sample: Consistency of findings in women and men. *Psychological Medicine*, 27(6), 1381–1396.

Heath, A. C., Madden, P. A., Slutske, W. S., & Martin, N. G. (1995). Personality and the inheritance of smoking behavior: A genetic perspective. *Behavior Genetics*, *25*(2), 103–117.

Jacobson, K. C., Prescott, C. A., & Kendler, K. S. (2000). Genetic and environmental influences on juvenile antisocial behaviour assessed on two occasions. *Psychological Medicine, 30*(6), 1315–1325.

Jang, K. L., Vernon, P. A., & Livesley, W. J. (2000). Personality disorder traits, family environment, and alcohol misuse: A multivariate behavioural genetic analysis. *Addiction*, *95*(6), 873–888.

Kendler, K. S., Gardner, C. O., & Prescott, C. A. (2002). Toward a comprehensive developmental model for major depression in women. *American Journal of Psychiatry, 159*(7), 1133–1145.

Kendler, K. S., Jacobson, K. C., Prescott, C. A., & Neale, M. C. (2003). Specificity of genetic and environmental risk factors for use and abuse/dependence of cannabis, cocaine, hallucinogens, sedatives, stimulants, and opiates in male twins. *American Journal of Psychiatry*, 160(4), 687–695.

Kendler, K. S., Karkowski, L. M., Neale, M. C., & Prescott, C. A. (2000). Illicit psychoactive substance use, heavy use, abuse, and dependence in a US population-based sample of male twins. *Archives of Genetic Psychiatry, 57*(3), 261–269.

Krueger, R. F., Hicks, B. M., Patrick, C. J., Carlson, S. R., Iacono, W. G., & McGue, M. (2002). Etiologic connections among substance dependence, antisocial behavior, and personality: Modeling the externalizing spectrum. *Journal of Abnormal Psychology*, 111(3), 411–424.

Laviola, G., Adriani, W., Terranova, M. L., & Gerra, G. (1999). Psychobiological risk factors for vulnerability to psychostimulants in human adolescents and animal models. *Neuroscience and Biobehavioral Reviews, 23*(7), 993–1010.

Loehlin, J. C., McCrae, R. R., Costa, P. T., & John, O. P. (1998). Heritabilities of common and measure-specific components of the Big Five personality factors. *Journal of Research in Personality, 32*, 431–453.

Lynskey, M. T., Fergusson, D. M., & Horwood, L. J. (1998). The origins of the correlations between tobacco, alcohol, and cannabis use during adolescence. *Journal of Child Psychology and Psychiatry, 39*(7), 995–1005.

McCrae, R. R., & Costa, P. T. (1990). *Personality in adulthood*. New York: The Guilford Press.

Miles, D. R., van den Bree, M. B., Gupman, A. E., Newlin, D. B., Glantz, M. D., & Pickens, R. W. (2001). A twin study on sensation seeking, risk taking behavior and marijuana use. *Drug and Alcohol Dependency*, 62(1), 57–68.

Mulder, R. T. (2002). Alcoholism and personality. *Australian and N.Z. Journal of Psychiatry, 36*(1), 44–52.

Mustanski, B. S., Viken, R. J., Kaprio, J., & Rose, R. J. (2003). Genetic influences on the association between personality risk factors and alcohol use and abuse. *Journal of Abnormal Psychology, 112*(2), 282–289.

Muthen, L. K., & Muthen, B. O. (1998). *Mplus: The Comprehensive Modeling Program for Applied Researchers (Version 2.13)*. Los Angeles, CA.

Neale, M. C. (1990). *Statistical modeling with Mx*. Department of Psychiatry, Box # 980710, Richmond VA 23298.

Neale, M. C., & Cardon, L. R. (1992). *Methodology for genetic studies of twins and families*. Netherlands: Kluwer Academic Publishers.

Neale, M. C., Roysamb, E., & Jacobson, K.C. (2003). *Multivariate genetic analysis of sex limitation in human populations*. Manuscript in preparation.

Oldehinkel, A. J., Bouhuys, A. L., Brilman, E. I., & Ormel, J. (2001). Functional disability and neuroticism as predictors of late-life depression. *American Journal of Geriatric Psychiatry, 9*(3), 241–248.

Petersen, T., Bottonari, K., Alpert, J. E., Fava, M., & Nierenberg, A. A. (2001). Use of the five-factory inventory in characterizing patients with major depressive disorder. *Comprehensive Psychiatry, 42*(6), 488–493.

Prescott, C. A., Neale, M. C., Corey, L. A., & Kendler, K. S. (1997). Predictors of problem drinking and alcohol dependence in a population-based sample of female twins. *Journal of Studies on Alcohol*, *58*(2), 167–181.

SAS Institute (1999). *SAS User Guide, Version 8.2*. Cary, NC: SAS Institute Inc.

Slutske, W. S., Heath, A. C., Madden, P. A., Bucholz, K. K., Statham, D. J., & Martin, N. G. (2002). Personality and the genetic risk for alcohol dependence. *Journal of Abnormal Psychology, 111*(1), 124–133.

Spitzer, R. L., Williams, J. B., & Gibbon, J. (1987). *Structured Clinical Interview for DSM-III-R: Patient Version (SCID-P)*. New York: New York State Psychiatric Institute.

Spotts, J. V., & Shontz, F. C. (1984). Drugs and personality: Extraversion-introversion. *Journal of Clinical Psychology, 40*(2), 624–628.

Spotts, J. V., & Shontz, F. C. (1991). Drugs and personality: Comparison of drug users, nonusers, and other clinical groups on the 16PF. *International Journal of Addiction, 26*(10), 1019–1054.

Stein, M. B., Chartier, M. J., Lizak, M. V., & Jang, K. L. (2001). Familial aggregation of anxiety-related quantitative traits in generalized social phobia: Clues to understanding "disorder" heritability? *American Journal of Medical Genetics, 105*(1), 79–83.

Tupes, E. C., & Christal, R. C. (1961). *Recurrent personality factors based on trait ratings*. Lackland Air Force Base, TX: U.S. Air Force.

Van, d. B., Oldehinkel, A. J., Bouhuys, A. L., Brilman, E. I., Beekman, A. T., & Ormel, J. (2001). Depression in later life: Three etiologically different subgroups. *Journal of Affective Disorders, 65*(1), 19–26.

Zuckerman, M. (1983). Sensation seeking: the initial motive for drug use. In E. H. Gottheil, K. A. Druley, T. E. Skolada, & H. M. Waxman (Eds.), *Etiological aspects of alcohol and drug abuse* (pp. 202–220). Springfield, IL: Charles C. Thomas.

Zuckerman, M. (1987a). Biological connection between sensation seeking and drug abuse. In J. Engle, L. Oreland, D. H. Ingvar, B. Pernow, S. Rossner, & L. A. Pellborn (Eds.), *Brain reward systems and abuse*. New York: Raven Press.

Zuckerman, M. (1987b). Is sensation seeking a predisposing trait for alcoholism. In E. H. Gottheil, K. A. Druley, S. Pashkey, & S. P. Weinstein (Eds.), *Stress and addiction.* New York: Bruner/Mazel.

Zuckerman, M. (1994). *Behavioral expressions and biosocial bases of sensation seeking*. New York: Cambridge University Press.

https://doi.org/10.1375/twin.7.1.72 Published online by Cambridge University Press