Behavior Genetics, Vol. 25, No. 4, 1995

A Multivariate Genetic Analysis of Sensation Seeking

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Received 24 July 1994—Final 31 Jan. 1995

The genetic architecture of sensation seeking was analyzed in 1591 adolescent twin pairs. Individual differences in sensation seeking were best explained by a simple additive genetic model. Between 48 and 63% of the total variance in sensation seeking subscales was attributable to genetic factors. There were no sex differences in the magnitude of the genetic and environmental effects. The different dimensions of sensation seeking were moderately correlated. The strongest correlations were between the subscales Thrill and Adventure Seeking and Experience Seeking ($r = 0.4$) and between Boredom Susceptibility and Disinhibition ($r = 0.4$ in males, $r = 0.5$ in females). A triangular decomposition showed that the correlations between the sensation seeking subscales were induced mainly by correlated genetic factors and, to a smaller extent, by correlated unique environmental factors. The genetic and environmental correlation structures differed between males and females. For females, higher genetic correlations for Experience Seeking with Boredom Susceptibility and Disinhibition and higher correlations among the unique environmental factors were found. There was no evidence that sex-specific genes influenced sensation seeking behavior in males and females.

KEY WORDS: Sensation seeking; adolescent twins; multivariate genetic analysis.

INTRODUCTION

Sensation seeking can be described as the need for new experiences, a nonconforming lifestyle, and the desire to engage in riskful activities. The Sensation Seeking Scale was developed by Zuckerman (1971) within the framework of studies on sensory deprivation, to assess individual differences in optimal levels of stimulation or arousal. Zuckerman (1971) postulated that "the need for change, variety and intensity of stimulation would manifest itself in many aspects of behavior, including sensory, social and thrill-seeking types of activity." The questionnaire measures four dimensions of sensation seeking, identified with factor analysis: Thrill and Adventure Seeking (TAS), Experience Seeking (ES), Boredom Susceptibility (BS), and Disinhibition (DIS) (Zuckerman, 1971; Zuckerman *et al.*, 1978). Zuckerman *et al.* (1978) described Thrill and Adventure Seeking as "the desire to engage in sports or other activities involving speed or danger." Experience Seeking is a measure of "the seeking of new experiences through the mind and senses, and through an unconventional, non-conforming life-style." Boredom Susceptibility assesses "the dislike of repetition of experience, routine work, predictable dull or boring people, and restlessness when things are boring." Disinhibition measures "the desire to find release through social disinhibition, drinking, going to parties and having a variety of sexual partners." A number of studies have shown that sensation seeking was related to psychophysiological and biochemical measures such as the orienting reflex, augmenting–reducing of the averaged evoked potential, and levels of

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0001-8244/95/0700-0349$07.50/0

monoamine oxidase and gonadal hormones (reviewed by Zuckerman, 1984; Zuckerman *et al.*, 1980). On the behavioral level there is a relation between high sensation seeking and a greater variety of heterosexual activities with more partners, multidrug use, and the tendency to experiment with different drugs, alcohol use, cigarette smoking, volunteering for experiments and unusual activities, physically dangerous activities, gambling, vocational interests, and social attitudes (Zuckerman, 1979; Zuckerman *et al.*, 1980). Scores on sensation seeking are sex and age dependent. The sex differences are most pronounced for TAS and DIS; males score higher on these scales than females (Zuckerman *et al.*, 1978). From the age of 16 through the early 20s there are no important changes, but after the age of 20 a decline in scores is evident (Zuckerman, 1979). Recent reviews of twin, family, and adoption studies showed that for personality traits, such as extraversion and neuroticism, almost 50% of the total variance can be explained by genetic factors (Loehlin, 1992; Eaves *et al.*, 1989). For sensation seeking itself, Fulker *et al.* (1980) estimated a heritability of 58% for the general scale of the Sensation Seeking Scale Form IV. As for most aspects of personality (Plomin and Daniels, 1987) there was no evidence for shared environmental influences on sensation seeking. This study was based on 422 pairs of adult twins from the Maudsley Twin Register (mean age, 31 years). There were more female twins (286 pairs) than males (85 pairs) and opposite-sex twins (51). A number of studies have described different analyses of the sensation seeking data of these twins (Zuckerman *et al.*, 1978; Eysenck and Zuckerman, 1978; Martin *et al.*, 1979; Eysenck, 1983; Resnick *et al.*, 1993). Eysenck (1983) reported for each dimension of sensation seeking the proportion of the total variance due to genetic effects. The heritability estimates were lowest for BS (0.41 for males, 0.34 for females) and highest for ES (0.58 for males, 0.57 for females). To our knowledge, there is only one other twin study of Zuckerman's Sensation Seeking Scale. This study by Buchsbaum (published by Zuckerman, 1974) was based on a small sample of 34 MZ and 30 DZ same-sex twins (half males, half females) of high-school age. The results showed a genetic influence on sensation seeking. For the general scale the heritability (Holzinger's h^2) was 0.28; for the subscales the h^2 ranged from −0.02 for ES to 0.40 for TAS.

In this paper we describe the genetic analyses of sensation seeking in 1700 pairs of adolescent twins. Sex differences in the genetic architecture of sensation seeking were analyzed by testing whether the magnitude of the genetic influences differed between males and females or whether different genes were expressed in males and females.

A multivariate model was used to determine to what extent the covariation between the subscales can be explained by correlated genetic and/or environmental factors (Martin and Eaves, 1977; Boomsma and Molenaar, 1986). The different subscales of sensation seeking are moderately correlated (Zuckerman *et al.*, 1978). They were not expected to be independent because Zuckerman (1971) hypothesized a second-order sensation seeking tendency underlying the four factors. The multivariate model is a more powerful method to calculate the proportions of the total variance due to genetic and environmental factors than separate univariate analyses for each variable, because it also takes the covariations between the variables into account. With a triangular decomposition (Neale and Cardon, 1992) we explored the genetic and environmental correlation structure between the different dimensions of sensation seeking. Zuckerman's hypothesis of a second-order factor model for the four subscales was tested with a common factor model.

METHODS

Subjects

This study is based on completed questionnaires on health and lifestyle, mailed in 1991 to adolescent twins and their parents (Boomsma *et al.*, 1994; Koopmans *et al.*, 1994). Twin families were recruited by asking all city councils (720) in The Netherlands for addresses of twins aged 12–22 years. A positive response was received from 252 city councils, which supplied 3859 addresses; 177 addresses were available from other sources. After contacting these families by letter, 2375 twin families indicated that they were willing to participate and 1700 families returned the questionnaires. The sample of participating families came from all regions of the Netherlands, including both rural and urban areas and two of the four biggest cities.

The questionnaire consisted of items on zygosity, health, alcohol and tobacco use, sports participation, and personality. Of the 1700 twin pairs who returned questionnaires, 1591 provided responses from both twins to the personality scales. The incomplete pairs did not differ significantly from the complete pairs with respect to the means and variances of the sensation seeking scales. The age of the twins was between 12 and 24 years, less than 4% of the sample was younger than 14 years and 7% was older than 21 years, and the mean age was 17.7 years (SD = 2.26). The sample was representative of the general population with regard to educational level of the parents: 13.9% of the fathers and 15.3% of the mothers had a basic education at the elementary school, 61.8% of the fathers and 72.5% of the mothers had a high school education, and 24.3% of the fathers and 12.1% of the mothers had attained a college or university level. In the same age group of the general population, these figures are 16.9, 60.6, and 22.5% for men, respectively, and 21.5, 64.4, and 13.9% for women (Netherlands Central Bureau of Statistics, 1994).

Zygosity of the twins was determined by questionnaire items about physical similarity and frequency of confusion of the twins by family and strangers (Goldsmith, 1991; Magnus *et al.*, 1983). The classification of zygosity was based on a discriminant analysis, relating the questionnaire items to zygosity based on blood-group polymorphisms and DNA fingerprinting in a group of 131 same-sex adolescent twin pairs who participated in a study of cardiovascular risk factors (Boomsma *et al.*, 1993). In that sample zygosity was correctly classified by questionnaire in 95% of the cases. We looked at the validity of the zygosity questionnaire in a subsample of 86 same-sex twins, aged 16 years, who participated both in our study and in a longitudinal study of brain function (van Beijsterveldt *et al.*, 1994, submitted). For these twins, agreement between zygosity based on the questionnaire and zygosity based on blood-group polymorphisms was 88%. Of the 10 pairs who were misclassified by questionnaire, 9 pairs were MZ twins mistakenly assigned as DZ twins. The total sample consisted of 275 monozygotic male twins, 258 dizygotic male twins, 360 monozygotic female twins, 322 dizygotic female twins, and 485 opposite-sex twins. All five zygosity groups were well represented in our sample; there were only slightly more female twins (40.1%) than male twins (31.4%). The proportion of opposite-sex twins in our sample (28.5%) was almost equal to the proportion of opposite-sex twins in the total population of twins born between 1970 and 1980 in The Netherlands (29.5%) (Tas, 1990).

Table I. Summary Statistics for the Sensation Seeking Scales in Males (N=1475) and Females (N=1799)[a]

	No. of items	Min–max	Male Mean	Male SD	Female Mean	Female SD
TAS	12	12–60	41.49 (39.93)	9.07 (8.84)	36.96 (37.75)	9.73 (9.59)
ES	14	14–64	34.86 (45.51)	7.10 (8.89)	34.27 (45.09)	7.45 (8.18)
BS	13	13–64	38.59 (40.82)	6.74 (7.73)	37.93 (41.33)	7.45 (7.51)
DIS	12	12–58	35.35 (37.09)	7.28 (8.10)	30.64 (34.07)	6.69 (7.40)

[a] Means and SD of the norm sample (Feij *et al.*, 1982) in parentheses (174 males, 147 females). TAS, Thrill and Adventure Seeking; ES, Experience Seeking; BS, Boredom Susceptibility; DIS, Disinhibition.

Measures

Sensation Seeking was surveyed with the Dutch version of Zuckerman's Sensation Seeking Scale, form IV (Feij and van Zuilen, 1984). The Dutch scale consists of 67 Likert-type items, covering Thrill and Adventure Seeking (TAS), Experience Seeking (ES), Boredom Susceptibility (BS), and Disinhibition (DIS). There is no overlap between the items of the subscales. The four scales in the Dutch version of the Sensation Seeking Scale have reasonably high internal consistencies (between 0.72 and 0.81) (Feij *et al.*, 1982). Table I presents the summary statistics for each sensation seeking scale. Each item has to be answered on a scale from 1 to 5, giving, for example, for TAS (12 items) a minimal score of 12 and a maximal score of 60. Compared with a Dutch sample on which the construction of the scale was based (Feij *et al.*, 1982) the means for TAS were about the same, whereas for ES, BS, and DIS the means in our sample were lower. This might be explained by the different samples that were surveyed; the norm sample consisted of 331 (174 males and 147 females) first-year undergraduate psychology students with a mean age of 21.5 years (SD = 4.6 years), while our sample is younger and based on the general population. For each scale a model was fitted to the means, variances, and covariances of the five zygosity groups. Within the most saturated genetic model (a model with additive genetic, shared environmental, and unique environmental factors with sex differences), the heterogeneity of means was tested (Neale and Cardon, 1992). In the first model 10 means (for first- and second-born twins in the five zygosity groups) were estimated, giving a perfect fit to the data with regard to the mean structure. The second model tested whether the means for the first- and second-born twins can be equated for same-sex twins. In the next step the mean of the male opposite-sex twins was equated to the mean of the same-sex DZ male twins, and the same was done for females. Next, it was tested whether the means differ between MZ and DZ twins, for males and females separately. Finally, the means for males and females were equated. For TAS, BS, and DIS there were no significant differences between first- and second-born twins and between MZ and DZ twins. This was also true for the means of ES in the same-sex twins. For ES the means in opposite-sex twins were significantly different from the means in same-sex DZ twins ($\Delta^2_\chi = 8.46$, df $= 2$, $p < .05$). Male opposite-sex twins had a higher mean (35.30) than the male same-sex DZ twins (34.34), while means for female opposite sex-twins (34.00) were reduced compared to female same-sex DZ twins (34.98). For same-sex twins there were no significant sex differences for ES. Differences between males and females were significant for TAS ($\Delta^2_\chi = 154.38$, df $= 9$, $p < .001$) and for DIS ($\Delta^2_\chi = 262.11$, df $= 9$, $p < .001$).

Genetic Analysis

The variances and covariances of the four sensation seeking scales were calculated for each zygosity group with PRELIS 1.2 (Jöreskog and Sörbom, 1986), resulting in 8×8 twin pair covariances matrices (four scales for the first twin and for the second twin). Same-sex twins were assigned as first or second twin based on the birth order. Opposite-sex pairs were reordered so that the male twin was the first twin and the female twin the second twin. To test whether the correlations between the sensation seeking scales were induced by correlated genetic and environmental factors, a triangular or Cholesky decomposition was carried out on the covariance matrices (Neale and Cardon, 1992). A Cholesky factorization decomposes the

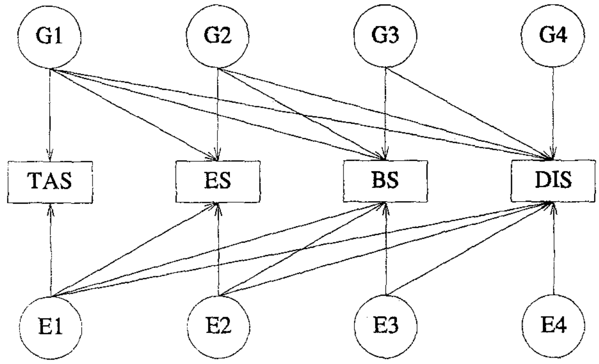

Fig. 1. Triangular decomposition of the genetic and environmental factors for the four sensation seeking scales: Thrill and Adventure Seeking (TAS), Experience Seeking (ES), Boredom Susceptibility (BS), and Disinhibition (DIS).

genetic and environmental covariance matrices into triangular matrices of factor loadings. The number of factors equals the number of variables. Figure 1 shows the triangular decomposition of the genetic and environmental factors for the four sensation seeking variables. The first factor contributes to all four variables, the second factor influences the subsequent three variables, and so on. The genetic or environmental covariance matrix is calculated by the product of the triangular matrix and its transpose. Mx (Neale, 1993) was used to fit the Cholesky decomposition with additive genetic, shared environmental, and unique environmental factors to the data. Goodness of fit was assessed by likelihood-ratio chi-square tests. To test Zuckerman's hypothesis of a second-order sensation seeking factor, we fitted a genetic common factor model. In this model one common genetic factor was specified that influences the four sensation seeking scales and one common unique environmental factor. In addition, unique genetic and unique environmental variances were allowed for each scale.

Different sex-limitation models were tested. In the scalar model the female variances were constrained to be equal to a scalar multiple of the male variance components (Neale and Cardon, 1992). In this model the total variances may differ between males and females but the proportions of the total variance due to genetic and environmental effects are the same. The general sex-limitation model tested whether the magnitude of the genetic and environmental effects differs between males and females and whether different genes or environmental factors operate in males and females. The latter was modeled as an imperfect correlation between the genetic factors in opposite-sex twins. In this model the first genetic factor in males was correlated with the first genetic factor in females, the second genetic factor in males with the second genetic factor in females, and so on. This is a reduced model of the full model in which each genetic factor in males is allowed to correlate with all the four genetic factors in females.

The correlation between age and the sensation seeking scales ranged from −0.14 to −0.12 in females and from −0.09 to 0.01 in males. Although the correlations in females were significantly different from zero ($\chi^2 = 43.47$, df = 4, $p < .001$), they were weak and therefore were not included in the analyses.

RESULTS

The twin correlations for each zygosity group are presented in Table II. Overall the MZ correlations were about twice the DZ correlations, suggesting that genetic factors influence individual differences in sensation seeking. Table III shows the phenotypic correlations between the four sensation seeking scales. The correlations were moderate, ranging from 0.16 to 0.46. Thrill and Adventure Seeking correlated highest with Experience Seeking ($r = 0.40$), and Disinhibition correlated highest with Boredom Susceptibility ($r = 0.41$ in males, $r = 0.46$ in females). Although the pattern of correlations looked the same for males and females, the correlations could not be constrained to be equal across the sexes ($\Delta^2_\chi = 22.31$, df = 6, $p < .05$).

Table IV presents the goodness-of-fit indices of the different multivariate models that were fitted to the data. A Cholesky decomposition model with additive genetic, shared environmental, and unique environmental factors that were constrained to be equal in males and females gave a poor fit (model 1). A sex-limitation model in which the correlational structure was constrained to be equal in males and females but the variances for the males were allowed to differ from the female variances gave a significantly better fit (model 2) but was still worse than model 3, which allowed for sex-specific parameter estimates ($\Delta^2_\chi = 45.31$, df = 30, $p < .05$). Model 3 is the full Cholesky decomposition with sex-specific estimates for the factor loadings, allowing the genetic correlations between males and females to be less than 0.5. Constraining the genetic correlations to be 0.5 (model 4) did not reduce the fit of the model significantly. Without a significant loss of fit, the shared environment component could be set to zero, for both males and females (model 5). A common factor model, with a common genetic factor, a common unique environmental factor, and unique genetic and environmental variances did not fit the data. In summary, a triangular decomposition with additive genetic and unique environmental factors gave the best de-

Table II. Twin Correlations for Each Zygosity Group[a]

	MZM (260)[b]	DZM (230)	MZF (348)	DZF (304)	DZMF (449)
TAS	0.62	0.42	0.63	0.31	0.25
ES	0.53	0.35	0.60	0.29	0.25
BS	0.45	0.33	0.55	0.34	0.24
DIS	0.59	0.42	0.58	0.45	0.30

[a] MZM, monozygotic males; DZM, dizygotic males; MZF, monozygotic females; DZF, dizygotic females; DZMF, dizygotic male-female twins.
[b] Number of complete pairs in parentheses.

Table III. Phenotypic Intercorrelations for the Sensation Seeking Scales: Correlations for Males (N=1475) in the Lower Triangle and for Females (N=1799) in the Upper Triangle[a]

	TAS	ES	BS	DIS
TAS	—	0.40	0.22	0.26
ES	0.40	—	0.34	0.34
BS	0.16	0.23	—	0.46
DIS	0.27	0.22	0.41	—

[a] TAS, Thrill and Adventure Seeking; ES, Experience Seeking; BS, Boredom Susceptibility; DIS, Disinhibition.

Table IV. Multivariate Model-Fitting Results[a]

Model	χ^2	df	p	AIC
1. No sex differences, *ACE*	184.33	150	0.03	−115.67
2. Scalar model, *ACE*	146.17	146	0.48	−145.83
3. Six-differences, r(g) free, *ACE*	100.83	116	0.84	−131.17
4. Six differences, r(g)=0.5, *ACE*	106.33	120	0.81	−133.67
5. No *C* in males & females	130.45	140	0.71	−149.55
6. Common factor model, *AE*	282.76	148	0.00	−13.24

[a] *A*, additive genetic factors; *C*, common environmental factors; *E*, unique environmental factors; r(g), genetic correlation between males and females of opposite-sex twins.

scription of the observed pattern of variances and covariances in MZ and DZ twins.

The standardized variance components for the best-fitting model are presented in Table V. For each scale the additive genetic and the unique environmental standardized variance components are summed over the four factors, giving the proportions of the total variance. For males additive genetic factors explained 62, 56, 48, and 62% of the total variance of TAS, ES, BS, and DIS, respectively. For females 63, 58, 54, and 60% of the total variance of these traits is attributable to additive genetic factors.

Table V also shows the genetic and unique environmental correlations between the dimensions of sensation seeking. The highest genetic correlations for males were between BS and DIS (r = 0.54) and between TAS and ES (r = 0.51). For females these correlations were 0.55 and 0.45, respectively. Additionally, in females ES correlated 0.47 with BS and 0.48 with DIS. Other genetic correlations were more modest. The unique environmental correlations were smaller than the genetic correlations, but they were still significant. Fitting a model with independent unique environmental factors, by estimating only the diagonal elements for these factors in males and females, gave a significant increase in the χ^2 of 165.31 for 12 df, compared with model 4.

DISCUSSION

Genes play a major role in the individual differences in sensation seeking. Between 48 and 63% of the total variance in sensation seeking scales was explained by genetic influences. This is comparable to the heritability estimate of 58% for the general scale of sensation seeking found by Fulker *et al.* (1980). The heritabilities for the subscales in the Fulker *et al.* study (reported by Eysenck, 1983) were somewhat lower than the ones we found, except for Experience Seeking. In our study the genetic variance was highest for Thrill and Adventure Seeking (62% for males, 63% for females) and Disinhibition (62% and 60%) and lowest for Boredom Susceptibility (48% for males, 54% for females). Eysenck reports the highest heritabilities for Experience Seeking (58 and 57%) and the lowest for Boredom Susceptibility (41 and 34%). For Thrill and Adventure Seeking and Disinhibition he found heritabilities between 51 and 41%.

The heritabilities for the sensation seeking subscales in twins aged 12 to 24 years are consistent with twin studies of other personality traits in adolescence. In the London Twin Study (262 pairs, aged 7–17 years) heritabilities for extraversion and neuroticism were 54 and 44%, respectively (Eaves *et al.*, 1989). A reanalysis of Loehlin and Nichols study (1976) of 850 pairs of high school juniors (18 years old) showed heritabilities of 61% for extraversion and 52% for neuroticism (Eaves *et al.*, 1989).

Although the pattern of twin correlations in Table II suggests that, especially in males, there might be some influence of shared environment, we did not observe a significant contribution of shared family environment on individual differences in sensation seeking in the model-fitting results. In the triangular decomposition of the data the shared environment matrix could be dropped in both sexes without a significant increase in chi-square. However, for personality traits, such as extraversion or neuroticism, the pattern of MZ and DZ correlations typically is somewhat different from what we observe. For sensation seeking we find high DZ correlations relative to the MZ correlations whereas for most other personality traits the DZ correlation usually is lower than half the MZ correlation (Loehlin, 1993).

Testing for sex differences in the genetic architecture of sensation seeking showed no evidence that different genes influence sensation seeking behavior in males and females. Allowing the correlation between the genetic factors in males and females to be less than one-half did not improve the goodness of fit compared to a model in which the genetic correlation was constrained to be 0.5. Although we fitted a reduced model in which four genetic correlations between males and females were estimated, this model fits the data very well.

The differences in the magnitude of the genetic effects in males and females were very small. Univariate genetic analyses for the subscales showed heritabilities to be the same in males and females (with a scalar model accounting for differences in total variance between the sexes in Thrill and Adventure Seeking, Boredom Susceptibility, and Disinhibition). The significant sex differences in the multivariate analysis were thus caused by differences in the pattern of genetic and environmental correlations. The higher phenotypic correlations in females are explained by higher

Table V. Standardized Variance Components, and Genetic and Environmental Correlations Between the Sensation Seeking Scales for Males and Females Under the Best-Fitting Model[a]

	Variance component		Genetic correlation				Unique environmental correlation			
	A	*E*	TAS	ES	BS	DIS	TAS	ES	BS	DIS
Males										
TAS	0.62	0.38	1.00				1.00			
ES	0.56	0.44	0.51	1.00			0.22	1.00		
BS	0.48	0.52	0.24	0.35	1.00		0.06	0.11	1.00	
DIS	0.62	0.38	0.37	0.32	0.54	1.00	0.12	0.08	0.26	1.00
Females										
TAS	0.63	0.37	1.00				1.00			
ES	0.58	0.42	0.45	1.00			0.32	1.00		
BS	0.54	0.46	0.29	0.47	1.00		0.12	0.16	1.00	
DIS	0.60	0.40	0.34	0.48	0.55	1.00	0.12	0.12	0.34	1.00

[a] *A*, proportion of total variance attributable to additive genetic factors; *E*, proportion of total variance due to unique environmental factors; TAS, Thrill and Adventure Seeking; ES, Experience Seeking; BS, Boredom Susceptibility; DIS, Disinhibition.

correlations among unique environmental factors for females than for males and by higher genetic correlations for Experience Seeking with Boredom Susceptibility and Disinhibition in females.

Males scored higher on Thrill and Adventure Seeking and Disinhibition than females. These sex differences in means in our sample are in accordance with what is generally observed for sensation seeking (Zuckerman *et al.*, 1978; Zuckerman, 1979). Recently, Resnick *et al.* (1993) reanalyzed the sensation seeking data of the 422 twin pairs, including 51 opposite-sex pairs, studied by Fulker *et al.* (1980). They found a higher level of Disinhibition, Experience Seeking, and overall sensation seeking in female members of opposite-sex twins. It was hypothesized that this increase was due to influences of prenatal androgen exposure. We found no evidence for increased sensation seeking in female members of 449 opposite-sex pairs. Testing for heterogeneity of means across zygosity groups and across males and females did not show any significant differences between females of opposite-sex twins and female same-sex DZ twins. The differences we found for Experience Seeking were in the opposite direction; females of opposite-sex twins had lower means compared to female same-sex DZ twins. Our study is based on adolescents, while Resnick and co-workers' (1993) study was based on adults, but it seems unlikely that this difference could explain the discrepancy in results.

Sensation seeking is positively related to extraversion, phychoticism, and impulsivity, but not to neuroticism (Eysenck and Zuckerman, 1978; Zuckerman, 1979; Martin *et al.*, 1979; Haapsalo, 1990). For extraversion and neuroticism the influence of heredity is well established; genetic factors explain almost 50% of the total variance of these traits (Loehlin, 1992; Eaves *et al.*, 1989). Martin *et al.* (1979) tested the hypothesis that the covariation between impulsiveness and sensation seeking could be explained in terms of an extraversion factor. They did not find much evidence for this hypothesis and concluded that impulsiveness and sensation seeking are not simple reflections of extraversion. Phenotypically, Thrill and Adventure Seeking correlated highest with Experience Seeking, and Boredom Susceptibility correlated highest with Disinhibition. These phenotypic correlations were induced mainly by correlated genetic factors and, to a smaller extent, by correlated unique environmental factors. The genetic correlations were substantial, but not as large as one would expect when the traits are entirely under the control of the same genetic factors. We fitted a genetic common factor model and found no evidence for one genetic factor underlying the genetic constitution that influences the different dimensions of sensation seeking. Eysenck (1983) also did not find much evidence for one genetic factor underlying the sensation seeking subscales. These results do not support Zuckerman's hypothesis of a second-order sensation seeking factor underlying the four subscales. Although all four dimensions of sensation seeking are positively correlated and were in fact originally developed by Zuckerman (1971) as part of one scale, our study shows that there is not one underlying genetic dimension of sensation seeking that can explain the covariation between the sensation seeking subscales.

ACKNOWLEDGMENT

This study was supported by the Dutch Heart Foundation and Medical Research NWO (Grant NWO 904-61-072).

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Edited by Joanne Meyer