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Health Related Psychosocial Correlates of Neuroticism: A Study of Adult Male Twins in Finland

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Abstract. Some health related psychosocial correlates of the Eysenck neuroticism scale were examined in a questionnaire study of 1501 monozygotic (MZ) and 3455 dizygotic (DZ) male twin pairs representing the adult male twin population in Finland. In analyses of the individuals, 34% of the variance in neuroticism was associated to: psychological variables (stress of daily activities, life satisfaction, quality of sleep, and extroversion – the explanatory rate of this variable set was 30%), psychotropic drugs (5%), alcohol use (4%), and smoking (2%). Neuroticism was also associated to social, life change, and medical variables. In pairwise analyses, the heritability estimate (h^2) was 0.54 for pairs living together and 0.39 for pairs living apart. It seems that heritability estimates are confounded by the closer intrapair relationship between members of MZ than DZ pairs. In pairwise analyses, 23% of the intrapair difference of neuroticism in MZ pairs was associated to intrapair differences in the aforementioned variables. The following explanatory rates were found: psychological variables, 21%; psychotropic drugs, 2%; alcohol use, 2%; and smoking, 1%. Neuroticism of pairs discordant for background variables showed similar intrapair differences as between individuals in the following variables: service vs farming work, use of alcohol, use of antacids, hypertension, heavy physical work, quality of sleep, changes of workplace for negative reasons, smoking, and use of tranquillizers. It appears that in Finland environmental factors explain at least 61% of the variability in neuroticism, and that factors determining neuroticism are also associated to health related behavior such as smoking, use of alcohol and psychotropic drugs.

Key words: Neuroticism, Psychosocial factors, Smoking, Alcohol, Heritability, Discordant twin pair analysis

INTRODUCTION

Neuroticism is one of the dimensions of Eysenck's personality theory [8,9], according to

which it is determined mainly by genetic factors, with environmental factors playing only a modifying role, while other personality theories suggest that it is caused by psychopathology in environment. Neuroticism as a determinant of health behavior is associated to smoking [14,29] and to alcohol and durg use, and may be predictive for cardiovascular disease [16].

The purpose of this study was to evaluate the contribution of genetic and environmental factors in neuroticism. We examined health-related psychosocial correlates of neuroticism in the Finnish male twin population. The analyses included psychological variables, characteristics of work and occupation, life change variables, smoking, use of alcohol and psychotropic durgs, physical activity, and some somatic symptoms.

SUBJECTS AND METHODS

The study series

The study population was a part of a population sample gathered in the Finnish Twin Cohort Study, consisting of all Finnish adult same-sexed twin pairs born before 1958 with both members alive in 1967, as extensively described elsewhere [18-20,22]. A questionnaire was mailed in 1975 to all pairs with both members alive to confirm twinship, determine zygosity [30], and obtain data on health-related variables. The overall response rate was 89% Responses from 5419 male pairs, with both members respondent, were obtained. Of these, 4956 were classified as monozygotic (MZ, N = 1501) or dizygotic (DZ, N = 3455) pairs and were used in these analyses. The analyses of individuals were carried out using data from random members of each pair.

Measurement of neuroticism

Neuroticism was measured on a rating scale developed by Eysenck [9] and modified by Floderus [12] using ten items. The scale included also nine items for extroversion. An English translation of the neuroticism questions is given in Table 1. A positive answer to a question is indicative for neuroticism. The scale was thus a sum of ten dichotomous (0.1) variables.

Measurement of other variables

Education was measured by asking what schools the respondent had attended and this was converted into years of education. The occupation of the respondent was coded on a 10-category occupational classification and a 6-category social class classification. The current employment status, the physical nature of work, work time schedules, and experienced monotony of work, were also asked. Mother language was taken from official population records.

A life statisfaction scale [1] with four items, and a four-item scale measuring experienced stress of daily activities were used [22]. The number of hours slept and the subjective quality of sleep were asked. Marital status, and 10 reasons for change of place of residence and 9 for change of workplace were asked and the latter were later grouped as positive or negative. Coronary-prone behavior (type A) using a 7-item Bortner scale [2] was measured [23].

The number of days per month during which spirits, wines and beer were used and the average amounts per month were recorded. Cigarette, pipe, and cigar smoking were measured separately. The average amount smoked daily was asked for both former and current smokers. The frequency of leisure-time physical activity based on the number of sessions of physical activity per month and their average duration was asked. The intensity was judged as referred to running or jogging or walking and by asking whether it caused perspiration and breathlessness [19]. Weight, height, the daily consumption of coffee and tea, and the frequency of use of 9 drug groups were asked. Angina pectoris, chest pain of possible infarction, chronic bronchitis, and breathlessness were measured [3,28].

Statistical methods

The difference of mean scores in subgroups was evaluated using Student's t-test and analysis of variance. The analyses were performed by age group but the results are age-adjusted by direct standardization. In discordant pair analysis, the intrapair difference was tested with Student's matched pair t-test. Multiple regression analysis was used in studying the multivariate relationships of the variables in relation to neuroticism. Heritability estimates [11] were calculated using intraclass correlations. Differences between MZ and DZ intraclass correlations were tested with Fisher's z-test. Regression

analysis was also used to compare the intrapair difference in neuroticism to those in other variables. The effect of common environment was calculated using the formula: $c^2 = 2r_{DZ} - r_{MZ}$.

RESULTS

Neuroticism scale

All items correlated positively to the sum score and to each other (Table 1). Item 4 had the highest correlation (r = 0.66) to the sum score, and item 8 the lowest (r = 0.45). The reliability coefficient (Chronbach's alfa) of the neuroticism scale was 0.73 in the whole material and it varied little in different age groups. The distribution of sum scores was weakly skewed to the right (range 0-10, mean 4.1). Mean scores showed minimal age trend: the lowest score was found for age 18-19 and the highest for age 55-59. Age and neuroticism had a very weak positive correlation ($r = 0.032$, $P < 0.05$; Table 2).

RESULTS OF INDIVIDUALS

Psychological and behavioral variables. Experienced stress of daily activities, life dissatisfaction and introversion were stronlgy associated to neuroticism (Table 2), and so were use of tranquillizers and sleeping pills, use of alcohol and smoking (Tables 2 and 3), as well as use of pain relievers and antacids (Table 3). Intensity in leisure time physical activity had low inverse correlation to neuroticism (Table 2, $P > 0.05$). Total amount of leisure time physical activity (intensity x number of sessions per month x average duration of a session) correlated inversely only among 18-24 year olds. A-type behavior score, the average amount of sleep, weight, height, and use of coffee and tea did not correlate to neuroticism.

Social variables. Neuroticism correlated significanlty to some social and occupational variables (Tables 2 and 4) and correlated inversely to education ($r = -0.060$, $p < 0.001$), and weakly inversely to income ($r = -0.04$, $P < 0.01$, Table 2). The following mean values were found in different educational groups: less than primary school, 4.7; primary school 4.2; primary school and at least one year occupational training, 4.0; junior high school, 4.3; junior high school and at least one year occupational training, 3.7; high school graduate 4.6; high school graduate and at least one year occupational training, 4.1; university degree, 3.5. Those persons who were not educated after secondary school or student exam had higher mean scores than persons with lower or higher education ($P < 0.01$).

The unemployed (4.8) had higher mean scores than persons at work (4.0, $P < 0.001$, Table 4). Farmers (3.5) and upper professionals (3.6) had the lowest mean scores, and persons working in mining (5.4), industry (4.3) and service (4.4) occupations had the highest mean scores (Table 4). These differences were highly significant. Persons working at nightwork (4.5) or shiftwork (4.5) had higher mean scores than persons working on normal time schedules (4.0, $P < 0.001$, Table 4). Physical activity at work and neuroticism had a weak positive correlation ($P < 0.001$) (Table 2), but heavy physical work showed high mean scores (Table 4). Subjective monotony of work associated to neuroticism ($P < 0.001$, Tables 2 and 4).

Divorced men had higher mean scores (5.1, $P < 0.001$) than married (4.0), single (4.2) and widowed (3.7) men (Tables 2 and 4). Change of place of residence for negative reasons and change of workplace for negative reasons were associated to neuroticism

($P < 0.001$, Tables 2 and 4). The number of all changes of place of residence or workplace correlated more weakly to neuroticism than the corresponding number of change for negative reasons.

Swedish speaking men had much lower mean scores (3.3) than Finnish speaking men (4.2, $P < 0.001$, Table 4).

Medical variables. Hypertension, angina pectoris and dyspnea were associated to neuroticism (Table 5). Men with a history of severe chest pain (5.7) had higher means than men without these symptoms (4.0, $P < 0.001$). Also men with chronic bronchitis (5.2) had higher mean scores ($P < 0.001$) than men without cough (4.0). Persons on illness or disability pension had higher neuroticism than persons at work (Table 5).

Those variables that showed a difference at least on the 5% level of significance in the univariate analysis were used in the multiple regression analyses to study multidimensional associations of neuroticism. In multiple stepwise regression analysis, 14 of them showed a statistically significant association to neuroticism with a cumulative explanatory rate of 33.7% (Table 6). The strongest associations were found for psychological variables: stress of daily activities, life satisfaction, quality of sleep, and extroversion. Regression analysis was done separately also in four variable sets (Table 11) showing the following explanatory rates: psychological variables, 29.8%; use of drugs, 4.7%; use of alcohol, 4.0%; and smoking, 2.1%.

The correlations of neuroticism and some selected variables are presented in Table 12.

Pairwise results

The pairwise intraclass correlations of neuroticism showed a slight decrease with increasing age for MZ ($P < 0.05$) and DZ ($P < 0.01$) pairs (Table 7). The heritability estimate [11] was 0.44 for all men, 0.54 for male pairs living together and 0.39 for those living apart. The estimate of the common environment effect (c^2) was close to zero. The heritability estimate showed a nonconsistent decrease with age.

The mean levels of neuroticism of members of pairs discordant for psychological, social and medical variables are shown in Tables 8-10. The comparison of the ratio of means of neuroticism of discordant MZ pairs, R_{MZ} (Tables 8-10) to the corresponding ratio in individuals, R_I (Tables 3-5) was made with following formula:

$$P = 100 \times [(R_{MZ} - 1) \ / \ (R_I - 1)]$$

P is thus the proportion (%) of mean intrapair difference of discordant MZ pairs from the corresponding interpair difference for the variable in question. This proportion was highest in the following variables: service work vs farming work (183%), use of hard liquors (98%), use of antacids (90%), hypertension (73%), heavy physical work (70%), changes of workplace for negative reasons (63%), smoking (63%), and use of tranquillizers (61%).

The intrapair difference in neuroticism was also compared to the intrapair differences in other variables using multiple stepwise regression analysis: intrapair differences of the psychological variables, smoking variables, alcohol variables, and variables of psychiatric drug use (Table 11) explained together 23.4% of the intrapair difference of neuroticism for MZ pairs and 28.6% for DZ pairs. The expalanation rate in each variable set was nearly on the same level in MZ and DZ pairs.

TABLE 1 - Correlation Coefficients Between Neuroticism Scale Items

Item	1	2	3	4	5	6	7	8	9	10
2	0.282									
3	0.241	0.176								
4	0.377	0.297	0.304							
5	0.242	0.212	0.223	0.312						
6	0.169	0.234	0.143	0.175	0.147					
7	0.347	0.242	0.146	0.258	0.209	0.254				
8	0.185	0.147	0.138	0.265	0.142	0.092	0.164			
9	0.211	0.152	0.128	0.268	0.174	0.143	0.203	0.267		
10	0.218	0.194	0.225	0.287	0.230	0.258	0.212	0.171	0.214	
Total	0.610	0.552	0.510	0.656	0.540	0.491	0.570	0.447	0.469	0.564

ITEMS:

1: Are you often uneasy, feeling that there is something you want without knowing it?
2: Are you sometimes happy or sometimes sad without a special reason?
3: Do you often reach decisions too late?
4: Do you often feel tired and listless without any special reason?
5: Are you often lost in your thoughts?
6: Are you extremely sensitive in any respect?
7: Are you ever too restless to sit still?
8: Do you have difficulties falling asleep?
9: Do you have nervous problems?
10: Do you usually worry a long time after a distressing incident?

TABLE 2 - Correlation of Neuroticism to Some Selected Variables (Number of cases 4956)

Stress of daily activities	0.430	***
Life satisfaction	−0.365	***
Quality of sleep	−0.344	***
Extroversion	−0.253	***
Frequency of use of tranquillizers	0.183	***
Heavy drinking	0.176	***
Frequency of use of sleeping pills	0.145	***
Monotony of work	0.143	***
Actual mean cigarettes per day	0.132	***
Number of change of workplace for negative reasons	0.116	***
Number of change of place of residence for negative reasons	0.112	***
Swedish speaking	−0.078	***
Divorce	0.073	***
Years of education	−0.060	***
Physical activity of work	0.047	***
Income	−0.038	**
Age	0.032	*
Intensity of leisure time physical activity	−0.015	ns

*** $P \leqslant 0.001$
** $P \leqslant 0.01$
* $P \leqslant 0.05$
ns $P > 0.05$

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TABLE 3 - Neuroticism in Individuals for Drug Use Variables (Age adjusted)

	Mean values of neuroticism	Ratio of means	P value
Use of sleeping pills /	6.9		
No use	4.0	1.72	***
Use of tranquillizers /	6.3		
No use	3.9	1.61	***
Use of pain relievers /	5.1		
No use	3.8	1.34	***
Use of antacids /	4.8		
No use	4.0	1.19	***
Regular use of hard liquors /	5.3		
No use or seldom use	3.7	1.41	***
Current or ex smoker /	4.3		
Nonsmoker	3.6	1.19	***

TABLE 4 - Neuroticism in Individuals for Some Social Variables (Age adjusted)

	Mean values of neuroticism	Ratio of means	P value
Divorced /	5.1		
Married	4.0	1.25	***
Monotonous work /	5.3		
Varying work	3.8	1.39	***
Unemployed /	4.8		
At work	4.0	1.21	***
Shiftwork or nightwork /	4.5		
Daywork	4.0	1.13	***
Service work /	4.4		
Farming work	3.6	1.23	***
Heavy physical work /	4.3		
Sedentary work	3.9	1.10	***
Changes of workplace for negative reasons /	4.3		
No negative changes	4.0	1.08	***
Primary school /	4.2		
University qualified	3.5	1.21	***
Mother language Finnish /	4.2		
Swedish	3.3	1.27	***

TABLE 5 - Neuroticism in Individuals for Some Medical Variables (Age adjusted)

	Mean values of neuroticism	Ratio of means	P value
Severe dyspnea /	6.8		
No dyspnea	4.2	1.60	***
Angina pectoris /	5.7		
No angina pectoris	4.0	1.41	***
Illness or disability pension /	5.5		
At work	4.0	1.37	***
Regular use of antihypertensive drugs /	4.7		
No use	4.1	1.15	***

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TABLE 6 - Multidimensional Associations of Neuroticism

Multiple stepwise regression analysis of selected variables and regression analyses of each variable set

Variables	Cumulative explanation rate	P value of variable entering the model
Stress of daily activities	18.5	***
Life satisfaction	24.6	***
Quality of sleep	28.2	***
Extroversion	29.8	***
Heavy drinking	31.2	***
Mother language Finnish	31.8	***
Physical activity at work	32.4	***
Frequency of use of tranquillizers (days/year)	32.8	***
Current or ex-smokers	33.1	***
Frequency of use of wine (days/month)	33.3	***
Subjective monotony of work	33.5	***
Frequency of use of liquor (days/month)	33.6	*
Frequency of use of antacids (days/year)	33.6	*
Change of place of residence for negative reasons	33.7	*
Unemployed	33.8	ns
Current smoker	33.8	ns
Frequency of use of beer (days/month)	33.8	ns
Frequency of use of pain relievers (days/year)	33.8	ns
Divorce	33.8	ns
Frequency of use of sleeping pills (days/year)	33.9	ns
Change of workplace for negative reasons	33.9	ns
Low amount of education	33.9	ns
Actual amount of consumed alcohol (g/month)	33.9	ns
Actual mean cigarettes per day	33.9	ns

Variable sets	Explanation rate for each variable set	P value
All psychological variables	29.8	***
All smoking variables	2.1	***
All alcohol variables	4.0	***
All psychiatric drug variables	4.7	***

TABLE 7 - Pairwise Comparison of Neuroticism Scale

Intraclass correlations, heritability (h^2) and effect of common environment (c^2)

Age group	MZ (r)	DZ (r)	h^2 $2(r_{MZ}-r_{DZ})$	c2 $2r_{DZ}-r_{MZ}$	z-test r_{MZ} vs r_{DZ} P value
18-19	0.541	0.314	0.454	0.087	**
20-24	0.538	0.251	0.574	−0.036	***
25-29	0.343	0.069	0.548	−0.205	***
30-34	0.369	0.210	0.318	0.051	*
35-39	0.328	0.204	0.248	0.080	ns
40-44	0.420	0.182	0.476	−0.056	**
45-49	0.298	0.146	0.304	−0.006	ns
50-54	0.377	0.200	0.354	0.023	ns
55-59	0.287	0.116	0.342	−0.055	ns
60-64	0.246	0.132	0.228	0.018	ns
65-69	0.376	0.087	0.578	−0.202	ns
Living together	0.551	0.279	0.544	0.007	***
Living apart	0.357	0.160	0.394	−0.037	***
Total	0.407	0.187	0.440	−0.033	***

TABLE 8 - Neuroticism in MZ and DZ Twins Discordant for Drug Use Variables

	MZ				DZ			
	Mean values of neurot-icism	Ratio of means	P	N	Mean values of neurot-icism	Ratio of means	P	N
Use of sleeping pills /	6.0				6.6			
No use	4.7	1.29	**	54	4.4	1.51	***	143
Use of tranquillizers /	6.3				6.3			
No use	4.6	1.37	***	87	4.4	1.44	***	277
Use of pain relievers /	4.5				4.8			
No use	4.0	1.12	*	152	4.0	1.19	***	460
Use of antacids /	4.8				4.9			
No use	4.0	1.18	*	129	4.5	1.11	**	345
Regular use of hard liquors /	5.2				5.5			
No use or seldom use	3.7	1.40	ns	6	3.6	1.52	*	28
Current or ex smoker /	4.1				4.1			
Nonsmoker	3.7	1.12	*	205	4.1	1.00	ns	811

TABLE 9 - Neuroticism in MZ and DZ Twins Discordant for Some Social Variables

	MZ				DZ			
	Mean values of neurot-icism	Ratio of means	P	N	Mean values of neurot-icism	Ratio of means	P	N
Divorced /	5.0				4.8			
Married	4.5	1.12	ns	65	4.7	1.03	ns	131
Monotonous work /	5.7				5.4			
Varying work	4.2	1.35	ns	14	4.7	1.16	ns	34
Unemployed /	4.6				5.0			
At work	4.5	1.02	ns	49	4.2	1.18	**	140
Shiftwork or nightwork /	4.6				4.4			
Daywork	4.4	1.04	ns	270	4.3	1.02	ns	741
Service work /	5.4				4.3			
Farming work	3.8	1.42	**	11	4.3	1.01	ns	25
Heavy physical work /	4.0				4.1			
Sedentary work	3.8	1.07	ns	54	3.9	1.05	ns	167
Changes of workplace for negative reasons /	4.4				4.6			
No negative changes	4.2	1.05	ns	483	4.1	1.11	***	1287
Primary school /					3.7			
University qualified				0	3.6	1.04	ns	25

TABLE 10 - Neuroticism in MZ and DZ Twins Discordant for Some Medical Variables

	MZ				DZ			
	Mean values of neurot-icism	Ratio of means	P	N	Mean values of neurot-icism	Ratio of means	P	N
Severe dyspnea /	6.2				6.2			
No dyspnea	5.2	1.19	ns	9	4.5	1.39	***	36
Angina pectoris /	5.3				5.4			
No angina pectoris	4.9	1.09	ns	114	4.2	1.30	***	274
Illness or disability pension /	4.8				5.4			
At work	4.3	1.12	ns	62	4.2	1.29	***	239
Regular use of antihypertensive drugs /	5.0				4.9			
No use	4.5	1.11	ns	28	4.0	1.22	*	132

TABLE 11 - **Associations of Intrapair Differences in Neuroticism and Selected Variables**
Regression analyses of intrapair difference of neuroticism among MZ and DZ pairs for each variable set

Variable set	Explanatory rate (%) for each variable set separately (and P value) of: intrapair difference of neuroticism among twin pairs by intrapair difference in selected variables			
	MZ		DZ	
All psychological variables[a]	20.9	***	26.3	***
Stress of daily activities	9.1	***	14.4	***
Life satisfaction	10.2	***	10.3	***
Extroversion	6.1	***	7.5	***
Subjective monotony of work	1.2	**	1.9	***
All smoking variables	1.0	***	0.4	**
All alcohol variables	2.3	***	1.6	***
All psychiatric drug variables	1.7	***	3.3	***
All variables	23.4	***	28.6	***

[a] Psychological variables analysed also separately.

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Table 12 - Correlations of Neuroticism and Some Selected Continuous Variables
(Number of cases 4956; P = 0.001 when r = 0.047)

1. Stress of daily activities
2. Life dissatisfaction
3. Extroversion
4. Frequency of use of tranquillizers
5. Heavy drinking
6. Frequency of use of sleeping pills
7. Monotony of work
8. Actual mean cigarettes per day
9. Number of change of workplace for negative reasons
10. Number of change of place of residence
11. Years of education
12. Physical activity of work
13. Income
14. Age
15. Intensity of leisure time physical activity
16. Neuroticism

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
1.	–														
2.	0.30	–													
3.	−0.16	−0.25	–												
4.	0.15	0.20	−0.04	–											
5.	0.14	0.14	0.07	0.04	–										
6.	0.11	0.15	−0.03	0.54	0.08	–									
7.	0.05	−0.19	−0.14	0.02	0.02	0.00	–								
8.	0.09	0.07	0.04	0.05	0.30	0.04	0.01	–							
9.	0.08	0.14	−0.06	0.09	0.12	0.07	0.05	0.17	–						
10.	0.09	0.11	−0.00	0.11	0.12	0.07	0.03	0.12	0.26	–					
11.	0.02	−0.10	0.04	−0.07	0.01	−0.05	−0.07	−0.13	−0.18	−0.11	–				
12.	−0.00	−0.15	−0.02	0.07	0.01	0.06	0.01	0.02	0.16	0.06	−0.36	–			
13.	0.09	−0.19	0.02	−0.09	0.09	−0.06	−0.14	0.13	−0.04	0.05	0.14	−0.31	–		
14.	0.06	−0.03	−0.07	0.10	−0.03	0.12	−0.11	0.11	0.18	0.16	−0.25	0.06	0.09	–	
15	0.02	−0.08	0.10	−0.06	−0.00	−0.04	−0.01	−0.12	−0.08	−0.05	0.29	−0.14	0.04	−0.19	–
16.	0.43	−0.37	−0.25	0.18	0.18	0.15	0.14	0.13	0.12	0.11	−0.06	0.05	−0.04	0.03	−0.02

DISCUSSION

The instrument used for the measurement of neuroticism was quite consistent when reliability coefficient is considered. The items six ("Are you extremely sensitive in any respect?") and eight ("Do you have difficulties falling asleep?") had the lowest correlation coefficients to other items.

The heritability estimates indicate that at least 61% of the variance of neuroticism can be explained by nongenetic factors. The interpretation of results, however, is difficult because the association of neuroticism to some variables may be explained by selection or by causal effects. As a whole, there are mainly three situations: 1) neuroticism may have a selective effect, 2) study variables may be indicators of etiological factors of neuroticism, 3) both explanations may operate at the same time.

If selection is operating, neuroticism is a powerful predictor of social role: persons with low neuroticism have a higher tendency to become white collar workers than blue collar workers. Prediction of neurosis for social well-being has been found to operate for up to 17 years of follow-up [6]. Environmental factors, such as a lack of social relationships [15] and life events [27], are suspected of being causal in the onset of neurosis. Some results are more probably explained by environmental factors than by selection: low means of neuroticism among farmers may be caused by a different way of life or the different rearing environment in families of farmers. High mean scores in service occupations may be caused by difficult demands of work. In the MZ group there were 11 pairs who were sons of farmers, with one cotwin remaining as farmer and the other changing to service work. The latter cotwins showed much higher scores in neuroticism. For certain results, it is not possible to state whether the association is causal or selective. For example, persons at nightwork and shiftwork had higher scores of neuroticism. The same difficulty is found with life change variables. Some somatic symptoms, however, seem to raise neuroticism scores, as persons with angina pectoris, severe chest pain, dyspnea, and chronic bronchitis showed very high socres of neuroticism. It is impossible to conclude in these cases for the causal role of neuroticism as data comes from a cross-sectional study. The difference of neurotcisim between Finnish speaking and Swedish speaking has been discussed earlier [33]. The difference may originate from linguistic differences in the questions, but more probably it is a cultural difference.

In some studies [5,10,14,26] an association between smoking and psychoneurotic symptoms has been found. Eysenck [10], however, did not find any association between neuroticism and smoking. A positive correlation of neuroticism to smoking and alcohol use in this study seems to mean that neuroticism has a clear effect on health related behavior in Finland. As neuroticism is suspected of being associated with sympathetic predominance [8,24], the association of these factors with smoking may have some effect on the high incidence of cardiovascular disesases in Finalnd [21]. Thus, the high mean scores in persons with cardiac symptoms or hypertension could also be in part causal, and not due solely to the anxiety of having such a symptom. In a 20-year follow-up study of 123 men [7], neuroticism predicted angina pectoris, but not other symptoms of coronary artery disease. In this connection, it is also interesting that in Finland there are higher mean scores of neuroticism than in Sweden [33]. In Finland the use of alcohol has been found to be associated to anxiety or nervousness [32], and the use of medicines to anxiety [17]. Those factors causing neuroticism seem to be etiologically important in smoking and alcohol and drug use. They should be taken into account in planning health education.

Its positive correlation to the use of psychiatric drugs means that neuroticism is an indicator of mental health. This corresponds to expectation and means that these correlations can be interpreted as validating the neuroticism scale.

The importance of heredity in neuroticism has been expressed strongly by genetically oriented groups in behavioral science [8,25]. The intraclass correlations for MZ and DZ pairs showed decreasing trend with increasing age. The mean values, however, showed minimal correlation to age. This finding is probably caused by environmental factors. In this study heritability estimates were similar to those of earlier studies [4,13]. The interpretation of the results of twin studies, however, is complex, because it seems that the similarity of MZ twins is due not only to genetic factors. The heritability and common environment estimates are normally based on the assumption that the intrapair variance of environmental factors is similar in MZ and DZ pairs. If this assumption is not true, the heritability estimate only shows roughly the theoretical upper estimate of the effect of genetic factors. In the subjects of this study, 25% of MZ pairs and 15% of DZ pairs have lived together for their whole life. Additionally, in those pairs living apart, the mean frequency of communication between cotwins was 2.2 per week for MZ and 1.4 for DZ pairs ($P < 0.001$). This suggests that MZ twins have a closer intrapair relationship than DZ twins [31]. We don't know whether these differences in intrapair relationship are also associated to factors determining neuroticism. When cohabitation was taken into account, the heritability estimate for neuroticism decreased from 0.44 to 0.39. If we had some other indicators of intrapair relations (eg, indicating learning of behavior), the heritability estimate might decrease even more. The calculated effect of common environment was very low. This is probably underestimated, because MZ pairs seem to have more similar intrapair environment than DZ pairs.

The heritability estimate can include the effect of interaction of enviromental and genetic factors, eg: an allergen + atopic constitution = allergic disease. The heritability estimate is always a relative estimate specific for a given population in a given environment. Thus, in a theoretical population with no environmental variance, the heritability of a trait would be 100%. If we assume that a certain environmental factor with no variance has a different level in two populations (eg, all people are under light stress or under heavy stress), the heritability estimate of traits, symptoms and signs influenced by stress would lead to different conclusions in the two alternative situations.

At present, it seems that genetic factors explain less than a half of the variance of neuroticism in Finland, and environmental factors more than one-half. As mentioned earlier, the genetic variance may be caused by genetic factors alone or by interaction of genetic and environmental factors. On the other hand, "environmental factors" include measurements errors and short-term random variation, in addition to the causal factors. In the analysis of discordant pairs, neuroticism was associated to use of antacids, introversion, use of alcohol, life and job dissatisfaction, and hypertension. As the differences in MZ pairs are caused by environment, it seems that these variables are most strongly correlated with environmental factors as the intrapair difference was nearly as large as the difference between pairs. Discordant pair analyses showed similar differences for MZ and DZ pairs in psychological and social variables, but higher differences for DZ pairs in medical variables. In these pairs, neuroticism was increased by a somatic symptom in affected cotwins and discordant MZ pairs showed less difference in the severity of the disease.

This cross-sectional analysis has some restrictions in the etiological sense, because

most variables were indicators of various psychosocial processes as neuroticism itself. Results demonstrated that neuroticism and health behavior and social role have many common denominators, independent of genetic factors. In the future there will be a great need for detailed longitudinal family studies to find factors determining neuroticism. The predictive value of neuroticism for psychiatric diseases and the role of neuroticism in the complex chain of risk factors for cardiovascular diseases should be tested in prospective studies.

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