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HERITABILITY OF ITEM RESPONSES ON THE EYSENCK PERSONALITY QUESTIONNAIRE

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Summary—We report estimates of the heritabilities and common environment variances for the 90 items of the Eysenck Personality Questionnaire. Responses from 627 pairs of twins were analysed using the biometrical genetic analysis based on the threshold model described by Falconer. Many of the items revealed very substantial heritabilities. No less than 67/90 had heritabilities >33%, 19 had >50% and a few were even >65%. Some of the useful implications of item heritabilities are discussed.

INTRODUCTION

Most research in personality is carried out at a level of the scale or factor. However, a large quantity of information is also available at the level of the single item. One reason for the relative neglect of item-level data is that error variance is thought to swamp true score variance, making items both unreliable and unrepresentative. Thus the rule in educational and personality testing is that the reliability of an instrument increases as the number of items increases (Gulliksen, 1950; Lord and Novick, 1968; Rushton, Brainerd and Pressley, 1983). There are occasions, however, when aggregating over items is unnecessary, and even undesirable. In clinical contexts for example, when highly robust phenomena such as reflexes and overlearned habits are being studied, it may often be more useful to focus on a specific response than on general characteristics of the person (Bandura, 1969; Mischel, 1968). Similarly, aggregation may not strengthen empirical relationships when potent, ego-involving events are being investigated, as in Epstein and Fenz's (1965) study of anxiety in sport parachuting. Likewise, there may be little gain from aggregating self-ratings or ratings by others when these are based on impressions gathered over several past observations. It is the latter consideration that compels the focus of the present paper.

If an item from a self-report inventory is salient for an individual, there may be reason to suppose that that item will be reliable. When a person is asked for biographical background information, e.g. their age, sex, education, religion, political affiliation etc., their single answer is highly informative, as can be their endorsement of specific items concerning behaviour. Meeting someone who revealed: 'I would enjoy sport parachuting' or 'I am the life and soul of a party' would convey important information. The current paper reports the degree to which such specific behaviours are inherited.

Most research on the heritability of personality takes place at a level of the scale. Twin studies, for example, have demonstrated substantial heritabilities (i.e. approx. 50%) for paper-and-pencil tests of aggression, altruism, anxiety, dominance, extraversion, intelligence, locus of control, political attitudes, sexuality, values and vocational interests, using such inventories as the Adjective Check List (ACL), the California Psychological Inventory (CPI) and the Eysenck Personality Questionnaire (EPQ) (Fulker, 1981; Loehlin and Nichols, 1976; Rushton, 1984). Since each scale is made up of many items, it follows that the heritability at the scale level must be some function of the heritability of each item.

Item heritabilities have been calculated before, although infrequently (Horn, Plomin and Rosenman, 1976; Loehlin, 1965; Loehlin and Nichols, 1976). Loehlin (1965), for example, clustered 35 groups of 3–6 items from the Thurstone Temperament Survey (TTS) and the Cattell Junior Personality Quiz (JPQ) based on high correlations among items. Next, he ranked the 35 clusters in terms of the heritability of the clusters and divided them into high- and low heritability matrices.

Table 1. High and low heritable items from the TTS and the JPQ and their twin factor loadings (after Loehlin, 1965)

Factor	Description	Loading
	High Heritable Items	
I. Extraversion	Optimistic, poised (TTS 108, 130, 133)	0.61
	Socially outgoing (TTS 9, −32, −71, 78)	0.42
	Has own opinions (JPQ 15, 30, 53)	0.42
	Quick thinking (TTS 58, 68, 122)	0.40
	Socially dominant (TTS 16, 41, 42, 43, 44, 53)	0.40
II. Temperament	Likes to take things slow (TTS −60, 85, 86)	0.38
	Gets going easily (JPQ 80, 98, −111)	0.36
	Adventurous, self-confident (JPQ −22, 37, 46)	0.29
	Socially dominant (TTS 16, 41, 42, 43, 44, 53)	0.29
III. Emotionality	Controls his impulses (JPQ 90, −109, 132, −133)	0.55
	Gets angry, frightened, upset (JPQ 8, −45, −54, 65)	−0.52
	Good social adjustment (JPQ 10, 12, −18, 47)	0.37
	Likes to work with tools (TTS 8, 36, 83)	0.33
IV. Physical Interest	Likes to work with tools (TTS 8, 36, 83)	0.36
	Intellectual interests (JPQ) 13, −17, 60)	−0.33
	Likes physical work (TTS 7, 5, 33)	0.28
	Impatient, impulsive (JPQ 9, −113, 131)	0.28
	Low Heritable Items	
I. Extraversion	Impulsive, outgoing (TTS 9, 10, 31, 52)	0.56
	Enjoys group activity (TTS 67, −110, 128)	0.51
	Seeks social stimulation (TTS 11, 23, 37, −55, −84)	0.53
	Shy (JPQ −11, 25, 32)	−0.42
	Good memory for recent events (TTS 91, 102, −124)	0.41
	Vigorous, active (TTS 61, 65, 89)	0.40
	Considers self fortunate (JPQ 107, 121, 130)	0.37
II. Emotionality	Feels restricted by adults and rules (JPQ 117, 135, 138)	0.44
	Nervous, suspicious, jumpy (JPQ 96, 108, 127)	0.42
	Shy (JPQ −11, 25, 32)	0.31
III. Physical Interest	Enjoys team sports (TTS 64, 91, 120)	0.55
	Vigorous, active (TTS 61, 65, 89)	0.37
	Likes racing, boxing, betting (TTS 90, 117, 119)	0.35
	Considers self fortunate (JPQ 107, 121, 130)	0.33
IV. Socialization	Likes school and teacher (JPQ 1, 34, −61)	0.44
	Good behavior (JPQ 6, −69, 71)	0.39
	Gets along well with parents (JPQ 97, 126, 129)	0.31

Finally, he factor analysed the two matrices and derived four factors from each, extraversion and emotionality being common to both sets of factors (see Table 1).

The major genetical analysis of items to date, however, was carried out by Loehlin and Nichols (1976) with 514 pairs of monozygotic (MZ) twins and 336 pairs of dizygotic (DZ) twins. Each participant took a wide range of personality, attitude and interest questionnaires as well as those dealing with cognitive abilities. Altogether nearly 2000 items were involved, for each of which Loehlin and Nichols (1976) provided, in an appendix, the intraclass correlation for four combinations of sex and zygosity. From these it is possible to gain an estimate of the heritability of each item using the formula $2(r_{MZ} - r_{DZ})$. In general, the items revealed an approx. 50% additive genetic component, and no common environmental variance. On average, the MZ twins were twice as similar as the DZ twins across the broad range of items—exactly as would be predicted by a simple additive genetic model. Loehlin and Nichols also attempted to assess the differential heritability of items, using the CPI item pool. Only the most test–retest reliable 179 of 468 non-duplicated CPI items were chosen. Then for two random halves of the sample they sorted these reliable items into those with high heritability and those with low, depending on whether they demonstrated a $\geqslant 0.20$ intraclass correlation difference between MZ and DZ twins, or no more than a 0.02 intraclass correlation difference; 16 items met the criterion for high heritability in both samples, and 11 for low. These are presented in Table 2.

Loehlin and Nichols (1976) suggested caution about their findings because the large number of items in the original pool meant many of those in Table 2 could be there because of chance. They judged more confidence in the items with low heritabilities as these seemed to express political and social opinions which, elsewhere, had also shown lower heritability. Loehlin (1985) reports failure to replicate item heritability clusters reported by Horn *et al.* (1976) using the National Merit data. However, fairly stringent criteria for replication were used. To compare the data from two samples, the fit of a model with one set of parameters (as used here) could be compared with a model

Table 2. High and low heritable items from the CPI (after Loehlin and Nichols, 1976)

High Heritable Items
A person needs to 'show off' a little now and then
I liked '*Alice in Wonderland*' by Lewis Carroll
It is hard for me to start a conversation with strangers
I think I would like the work of a school teacher
The idea of doing research appeals to me
I am likely not to speak to people until they speak to me
I have always tried to make the best school grades that I could
I enjoy a race or game better when I bet on it
I like to talk before groups of people
I would like to be an actor on the stage or in the movies
I have never done any heavy drinking
I think I am usually a leader in my group
I am quite a fast reader
I'm not the type to be a political leader
I must admit that I am a highly-strung person
I sweat very easily even on cool days
Low Heritable Items
I am very slow in making up my mind
A person who doesn't vote is not a good citizen
I do not like to see people carelessly dressed
I think I am stricter about right and wrong than most people
I fall in and out of love rather easily
I believe women should have as much sexual freedom as men
People have a real duty to take care of their aged parents, even if it means making some pretty big sacrifices
In school I found it very hard to talk before the class
I find that a well-ordered mode of life with regular hours is congenial to my temperament
It is pretty easy for people to win arguments with me
I had my own way as a child

containing two sets of parameters, one for each data set. Significant differences in fit between the two models would indicate failure to replicate.

In the studies discussed, approximate estimates of the item heritabilities were given and, as we have noted, the authors were cautious about the replicability of their findings. It is possible, however, to use model-fitting techniques to the genetical analysis of human behaviour which provide less biased estimates of the heritabilities involved and of the confidence with which they can be held (Eaves, Last, Young and Martin, 1978; Fulker, 1981; Jinks and Fulker, 1970). In our study, therefore, we use maximum likelihood estimates of the genetic and environmental contributions to the items on the EPQ (Eysenck and Eysenck, 1975).

METHOD

Subjects

Previously collected data from 627 pairs of twins drawn from the Twin Register at the Institute of Psychiatry, University of London, were made available to the authors. These twins had volunteered in response to news releases, advertising efforts and public appeals. Zygosity had been determined from an adaptation of the questionnaire methods described by Cederöf, Friberg, Jonsson and Kaij (1961), or by blood-typing (Kasriel and Eaves, 1976). The sample reflects the excess of MZ twins and of females that are typically seen in twin registers (Lykken, Tellegen and De Rubeis, 1978), with group sizes as follows: male MZ, 99; female MZ, 227; male DZ, 71; female DZ, 131; opposite sex DZ, 99.

Instruments

All *S*s had completed a 101-item Personality Questionnaire as part of the standardization procedure for the 90-item EPQ. The biometrical genetic analysis is restricted to the 90 items of the EPQ.

Analysis

The biometrical genetic analysis is based on the threshold model described by Falconer (1965). This model assumes an underlying normal distribution of liability to a characteristic, with a

threshold beyond which the character is manifest. In the present context, this threshold divides the population so that a response of 'No' is below the threshold, while a response of 'Yes' is above. The data for the model consist of five 2×2 contingency tables, one for each of the twin sex–zygosity groups. In the case of same-sex twins the two cells of the tables representing a twin-pair discordant for item response (twin 1, 'Yes'; twin 2, 'No'; or vice versa) are collated, and estimated as a single statistic. Each item, therefore, has 16 frequencies to which the model is fitted. The eight parameters estimated for the majority of items consist of six thresholds (reflecting the prevalence of 'Yes' responses for each type of twin), h^2, the square-root of the heritability, and c^2, the square-root of the common environment variance. The expected correlation of MZ twins is $h^2 + c^2$, while that of the DZ twins is $\frac{1}{2}h^2 + c^2$. The model is thus one of the additive genetic, common environment and specific environment components. Assortative mating, G–E covariance, G × E interaction, allelic and non-allelic interactions are all assumed to be absent or negligible. This model may be the most appropriate for exploratory analysis of twin data since very large samples are needed to estimate gentical dominance in place of common environment (Martin, Eaves, Kearsey and Davies, 1978). The expected frequency corresponding to each of the data cells was computed by numerical integration from the two thresholds and the correlation coefficient for each type of twin pair. Maximum likelihood estimates of the parameters were obtained by minimization of the function

$$F = \sum_{k=1}^{5} \sum_{i=1}^{2} \sum_{j=1}^{2} 2n_{ijk} \ln[((n_{ijk}/n_{..k})P_{ijk})],$$

in which n_{ijk} and p_{ijk} represent the observed frequency and expected proportion, respectively, for cell ij of the kth twin group, and $n_{..k}$ is the sample size of the kth group. This approximates to χ^2 for large samples, and has (n observations—m parameters—k groups =) 3 *df*. The minimization was performed by the computer program MINUIT (CERN, 1974).

Table 3. Items of the EPQ scale showing estimated proportions of additive genetic (h^2) and common environmental variation (c^2), the errors of these estimates, and χ^2 statistics of the goodness-of-fit of the model

No.	Item	Scale	h^2	SE	c^2	SE	χ^2	*df*
1	Do you have many different hobbies?	E	0.20	0.20	0.29	0.17	0.73	3
2	Do you stop to think things over before doing anything?	P	0.42	0.08	0.00	0.11	1.03	0
3	Does your mood often go up and down?	N	0.50	0.07	0.00	0.10	7.35	3
4	Have you ever taken the praise for something you knew someone else had really done?	L	0.43	0.10	0.00	0.70	7.34	3
5	Are you a talkative person?	E	0.50	0.07	0.00	0.20	7.78	3
6	Would being in debt worry you?	P	0.00	0.63	0.30	0.09	4.60	3
7	Do you ever feel 'just miserable' for no reason?	N	0.42	0.08	0.00	0.19	8.10	3
8	Were you ever greedy by helping yourself to more than your share of anything?	L	0.36	0.24	0.13	0.20	2.77	3
9	Do you lock up your house carefully at night?	P	0.30	0.31	0.26	0.27	4.56	3
10	Are you rather lively?	E	0.44	0.08	0.00	0.14	8.54	3
11	Would it upset you a lot to see a child or an animal suffer?	P	0.79	0.08	0.07	0.08	0.00	0
12	Do you often worry about things you should not have done or said?	N	0.34	0.21	0.10	0.17	0.42	3
13	If you say you will do something, do you always keep your promise no matter how inconvenient it might be?	L	0.57	0.08	0.00	0.63	2.30	3
14	Can you usually let yourself go and enjoy yourself at a lively party?	E	0.52	0.07	0.00	0.06	4.46	3
15	Are your an irritable person?	N	0.26	0.09	0.00	0.08	3.19	3
16	Have you ever blamed someone for doing something you knew was really your fault?	L	0.41	0.07	0.00	0.07	7.30	3
17	Do you enjoy meeting new people?	E	0.57	0.08	0.00	0.16	2.19	3
18	Do you believe insurance schemes are a good idea	P	0.23	0.61	0.26	0.31	2.01	3
19	Are your feelings easily hurt?	N	0.47	0.07	0.00	0.03	10.28	3
20	Are *all* your habits good and desirable ones?	L	0.47	0.42	0.08	0.57	1.40	3
21	Do you tend to keep in the background on social occasions?	E	0.48	0.07	0.00	0.06	6.81	3
22	Would you take drugs which may have strange or dangerous effects?	P	0.70	0.10	0.00	0.20	4.94	3
23	Do you often feel 'fed-up'?	N	0.39	0.07	0.00	0.07	3.64	3
24	Have you ever taken anything (even a pin or button) that belonged to someone else?	L	0.13	0.20	0.40	0.17	2.08	3
25	Do you like going out a lot?	E	0.52	0.15	0.00	0.56	1.79	3
26	Do you enjoy hurting people you love?	P*						
27	Are you often troubled about feelings of guilt?	N	0.15	0.27	0.16	0.23	2.97	3
28	Do you sometimes talk about things you know nothing about?	L	0.48	0.07	0.00	0.08	8.48	3
29	Do you prefer reading to meeting people?	E	0.49	0.20	0.03	0.70	0.26	3

(*continued*)

Table 3 (*continued*)

No.	Item	Scale	h^2	SE	c^2	SE	χ^2	*df*
30	Do you have enemies who want to harm you?	P	0.67	0.11	0.00	0.75	0.09	0
31	Would you call yourself a nervous person?	N	0.43	0.08	0.00	0.17	1.82	3
32	Do you have many friends?	E	0.50	0.75	0.09	0.71	1.40	3
33	Do you enjoy practical jokes that can sometimes really hurt people	P	0.36	0.68	0.26	0.63	0.00	0
34	Are you a worrier?	N	0.35	0.08	0.00	0.07	3.53	3
35	As a child did you do as you were told immediately and without grumbling?	L	0.55	0.07	0.00	0.10	1.91	3
36	Would you call yourself happy-go-lucky?	E	0.41	0.07	0.00	0.08	2.81	3
37	Do good manners and cleanliness matter much to you?	P	0.78	0.07	0.00	0.09	9.22	3
38	Do you worry about awful things that might happen?	N	0.28	0.08	0.00	0.07	6.10	3
39	Have you ever broken or lost something belonging to someone else?	L	0.24	0.24	0.14	0.19	3.71	3
40	Do you usually take the initiative in making new friends?	E	0.41	0.07	0.00	0.07	5.13	3
41	Would you call yourself tense or 'highly-strung'?	N	0.11	0.24	0.24	0.21	2.27	3
42	Are you mostly quiet when you are with other people?	E	0.40	0.08	0.00	0.66	3.88	3
43	Do you think marriage is old-fashioned and should be done away with?	P	0.67	0.25	0.00	0.99	0.01	0
44	Do you sometimes boast a little?	L	0.19	0.24	0.14	0.20	7.03	3
45	Can you easily get some life into a rather dull party?	E	0.55	0.07	0.00	0.08	1.89	3
46	Do people who drive carefully annoy you?	P	0.69	0.07	0.00	0.13	1.39	3
47	Do you worry about your health?	N	0.42	0.08	0.00	0.65	2.44	3
48	Have you ever said anything bad or nasty about anyone?	L	0.51	0.11	0.00	0.11	0.96	0
49	Do you like telling jokes and funny stories to your friends?	E	0.37	0.24	0.15	0.20	1.87	3
50	Do most things taste the same to you?	P	0.37	0.17	0.00	0.80	0.08	0
51	As a child were you ever cheeky to your parents?	L	0.46	0.33	0.07	0.52	0.37	3
52	Do you like mixing with people?	E	0.50	0.21	0.00	0.96	9.05	3
53	Does it worry you if you know there are mistakes in your work?	P	0.19	0.26	0.12	0.21	0.67	3
54	Do you suffer from sleeplessness?	N	0.34	0.10	0.00	0.65	1.47	3
55	Do you always wash before a meal?	L	0.45	0.32	0.05	0.55	0.74	3
56	Do you nearly always have a 'ready answer' when people talk to you?	E	0.45	0.14	0.00	0.86	0.68	3
57	Do you like to arrive at appointments in plenty of time?	P	0.41	0.11	0.00	0.19	5.09	3
58	Have you often felt listless and tired for no reason?	N	0.38	0.07	0.00	0.13	6.09	3
59	Have you ever cheated at a game?	L	0.38	0.27	0.23	0.23	7.35	3
60	Do you like doing things in which you have to act quickly?	E	0.00	0.79	0.30	0.09	0.96	3
61	Is (or was) your mother a good woman?	P	0.84	0.54	0.04	0.07	0.00	0
62	Do you often feel life is very dull?	N	0.43	0.08	0.00	0.80	7.03	3
63	Have you ever taken advantage of someone?	L	0.52	0.08	0.00	0.65	5.15	3
64	Do you often take on more activities than you have time for?	E	0.36	0.07	0.00	0.05	4.88	3
65	Are there several people who keep trying to avoid you?	P	0.00	0.81	0.34	0.16	0.12	0
66	Do you worry a lot about your looks?	N	0.50	0.07	0.00	0.14	2.39	3
67	Do you think people spend too much time safeguarding their future with savings and insurances?	P	0.32	0.18	0.00	0.91	2.17	3
68	Have you ever wished that you were dead?	N	0.47	0.27	0.07	0.20	4.12	3
69	Would you dodge paying taxes if you were sure you could never be found out?	L	0.70	0.06	0.00	0.17	1.61	3
70	Can you get a party going?	E	0.56	0.07	0.00	0.12	0.97	3
71	Do you try not to be rude to people?	P	0.36	0.13	0.00	0.66	0.22	0
72	Do you worry too long after an embarrassing experience?	N	0.45	0.07	0.00	0.07	5.21	3
73	Have you ever insisted on having your own way?	L	0.00	0.73	0.25	0.09	3.11	3
74	When you catch a train do you often arrive at the last minute?	P	0.61	0.07	0.00	0.11	11.44	3
75	Do you suffer from 'nerves'?	N	0.35	0.08	0.00	0.06	4.46	3
76	Do your friendships break up easily without it being your fault?	P						
77	Do you often feel lonely?	N	0.30	0.09	0.00	0.05	8.73	3
78	Do you always practice what you preach?	L	0.21	0.21	0.06	0.17	1.99	3
79	Do you sometimes like teasing animals?	P	0.47	0.20	0.00	0.95	2.03	3
80	Are you easily hurt when people find fault with you or the work you do?	N	0.45	0.07	0.00	0.09	2.68	3
81	Have you ever been late for an appointment or work?	L	0.42	0.13	0.00	0.83	5.53	3
82	Do you like plenty of bustle and excitement around you?	E	0.13	0.27	0.29	0.24	3.15	3
83	Would you like other people to be afraid of you?	P	0.31	0.63	0.26	0.61	0.88	3
84	Are you sometimes bubbling over with energy and sometimes very sluggish?	N	0.35	0.08	0.00	0.08	2.43	3
85	Do you sometimes put off until tomorrow what you ought to do today?	L	0.51	0.14	0.00	0.84	1.05	3
86	Do other people think of you as being very lively?	E	0.48	0.07	0.00	0.07	5.30	3
87	Do people tell you a lot of lies?	P	0.38	0.64	0.20	0.59	2.40	3
88	Are you touchy about some things?	N	0.33	0.09	0.00	0.06	2.40	3
89	Are you always willing to admit it when you have made a mistake?	L	0.33	0.08	0.00	0.05	8.04	3
90	Would you feel very sorry for an animal caught in a trap?	P	0.73	0.23	0.00	0.60	0.00	0

Certain items of the EPQ scales showed markedly skewed distributions, particularly those of the P scale. This is to be expected given the population mean of 3.11 and range of 0–25 (Eysenck and Eysenck, 1975) of this metric. In the event of an observed cell frquency of zero, the tetrachoric correlation is theoretically undefined, and the ML function inestimable. To avoid this problem, the twin groups were combined to simply MZ twins and DZ twins, and a reduced model with two thresholds, h^2 and c^2 (yielding no degrees of freedom) was fitted to those items with any cell frequency of zero. Two 'P' items remained unanalysable, with observed cell frequencies of 0, following this procedure, and were excluded from the analysis. The EPQ items, the scale on which they load, the estimates of the percentages of variance due to heritability and common environment (and their standard errors) and the χ^2 goodness-of-fit of the model, are shown in Table 3. The data are shown in Table 4 in order that alternative models may be fitted and comparisons with data collected from other samples may be made. By combination with other samples, parameters of genetic dominance or sex differences may be estimated.

DISCUSSION

Perhaps surprisingly, we have found many of the items to have quite substantial heritabilities. Most of the heritabilities were approx. 50%, and some were as high as 80%, although others were apparently not heritable. The errors on the heritabilities were generally in the range of 5–10%, so the results should be fairly reliable and replicable. E items are relatively consistent in the range of 30–60% heritable variation, with the exception of Items 60 and 82, which both seem associated with activity. Heritabilities of N items are generally slightly lower than those of E items. Several L and P items show considerable skew, and the h^2 estimates are therefore more variable and less reliable.

The question of whether common environmental variance is significant for any of the items may be examined by fitting a reduced model with no common environment. This was performed for those items with estimates of $c^2 > 20\%$ of variance, ignoring the highly skewed items with only 2 *df*. The results, shown in Table 5, indicate significant deterioration of fit for only one item. However, this does not mean that common environment can safely be assumed to be absent in those items with non-significant but non-zero estimates of common environmental variation. As noted elsewhere (Neale, 1985) estimates of heritability are less biased in the presence of environmental parameters even if these latter are not significant on the χ^2-difference test. Therefore, the h^2 estimates of Table 4 are to be preferred.

The potential uses of item heritabilities are numerous. To begin with, it is possible to examine whether similar personality dimensions are extracted from factor analysis of correlation matrices made up of high and low heritable items. This may lead to insights on the underlying structure of personality and its relation to the environment. Do genotypes produce a covarying environment, as might be expected from theories of reciprocal co-evolution (Lumsden and Wilson, 1981), or are the genetic and environmentally influenced personalities unrelated? Loehlin (1965) factor analysed two matrices differing in heritability and derived similar factors from each, two being Extraversion

Table 4. Frequencies of twin-pair response categories for items on the EPQ scale, shown separately for each of the five sex–zygosity groups

	MZ males				MZ females				DZ males				DZ Female				DZ Opp. Sex			
Item	NN	NY	YN	YY	NN	NY	YN	YY	NN	NY	YN	YY	NN	NY	YN	YY	NN	NY	YN	YY
1	22	21	14	42	69	38	35	85	23	12	14	22	30	21	28	52	19	14	19	46
2	6	7	12	73	28	30	36	132	0	16	10	45	13	19	23	75	5	14	16	63
3	24	23	17	35	57	38	24	106	15	20	14	22	27	17	33	53	12	25	18	43
4	51	17	14	17	145	26	33	21	40	10	9	11	83	17	21	9	45	21	25	8
5	24	11	22	41	55	33	37	102	13	16	19	21	24	30	29	47	27	13	18	39
6	8	19	15	57	3	16	9	199	12	13	14	31	6	10	7	108	4	13	14	67
7	39	24	20	16	44	30	33	119	23	18	16	14	26	27	26	52	20	30	15	34
8	22	13	16	48	61	36	42	88	7	12	17	35	25	24	20	62	8	11	18	62
9	9	16	9	61	31	30	22	141	4	9	10	44	11	14	24	79	10	10	8	67
10	17	15	10	56	39	37	39	111	14	9	11	35	17	29	27	57	9	24	20	46
11	4	4	4	87	1	1	0	225	5	2	6	58	0	2	8	121	0	6	6	87
12	17	21	12	49	20	27	28	152	12	15	11	33	10	23	19	78	6	14	11	68
13	15	13	14	56	26	23	25	153	11	10	11	39	13	10	36	72	17	18	24	39

(*continued*)

Table 4 (*continued*)

	MZ males				MZ females				DZ males				DZ Female				DZ Opp. Sex			
Item	NN	NY	YN	YY	NN	NY	YN	YY	NN	NY	YN	YY	NN	NY	YN	YY	NN	NY	YN	YY
14	16	15	10	58	49	33	34	109	12	13	13	33	15	26	28	62	5	22	15	57
15	61	15	14	8	123	33	43	28	38	12	15	6	66	24	32	8	55	17	18	8
16	38	15	14	32	101	36	44	45	20	20	16	15	61	22	27	21	29	21	30	18
17	6	10	7	76	19	19	22	161	4	10	8	49	5	17	22	86	5	8	14	71
18	4	10	9	74	7	16	10	190	3	10	9	49	6	10	15	98	5	7	10	76
19	38	18	16	27	40	29	30	127	18	24	15	14	12	21	28	70	18	27	23	30
20	65	12	13	9	160	26	18	21	46	11	9	5	85	11	25	8	70	13	8	6
21	40	10	16	33	68	43	37	78	20	13	15	23	35	29	35	30	33	27	19	20
22	82	4	5	7	208	8	6	3	56	8	6	1	110	10	10	1	85	6	5	3
23	46	16	18	18	76	33	46	72	23	21	16	11	39	31	28	33	25	31	16	27
24	6	6	7	79	29	21	40	136	6	7	9	49	16	12	20	83	6	8	19	65
25	16	10	15	58	49	35	37	105	7	14	13	37	21	23	21	65	9	19	16	55
26	94	2	1	2	214	5	3	4	65	4	1	0	124	6	1	0	96	2	1	0
27	51	15	23	10	86	37	47	55	34	18	12	7	47	22	31	31	35	24	16	24
28	30	12	13	44	74	38	44	71	21	12	13	25	35	40	23	33	21	21	27	30
29	70	9	11	7	131	33	28	33	46	10	10	5	88	20	16	7	66	13	13	7
30	75	11	5	7	203	6	11	6	60	5	4	1	123	7	1	0	82	8	7	2
31	69	9	12	9	125	35	35	31	47	8	11	5	63	26	28	14	55	21	14	9
32	12	9	11	66	30	29	26	141	4	6	8	52	8	19	19	85	5	14	6	74
33	71	9	12	6	211	2	10	4	54	10	3	4	122	6	3	0	75	12	7	4
34	44	21	13	21	42	43	35	105	29	17	11	14	21	26	37	47	18	24	24	32
35	62	8	13	15	118	36	29	42	40	15	10	6	74	21	24	12	62	14	17	6
36	38	17	14	28	95	31	48	51	19	16	17	18	45	32	30	23	28	17	26	28
37	8	9	5	77	13	7	9	198	3	10	8	50	2	4	3	122	1	18	9	71
38	52	17	20	10	83	45	39	60	36	14	15	6	39	29	30	33	32	32	21	13
39	15	15	10	59	30	43	37	117	7	11	10	43	20	21	26	64	7	20	15	57
40	30	14	17	37	73	38	44	71	23	19	15	14	35	33	22	41	22	24	28	25
41	79	7	11	1	138	34	30	24	52	7	8	4	82	16	23	10	71	14	10	4
42	44	25	10	20	84	35	45	59	25	15	13	17	49	31	32	19	44	20	16	19
43	88	2	5	3	205	7	9	4	60	10	1	0	115	6	6	3	91	4	3	0
44	3	17	14	65	39	36	37	115	4	15	12	40	17	22	25	67	12	13	18	56
45	49	14	13	21	138	25	31	32	35	12	15	9	74	21	23	12	48	18	22	10
46	67	14	4	13	177	17	15	18	35	16	10	10	96	18	13	4	67	11	14	7
47	38	16	22	23	108	35	37	45	36	12	12	11	60	20	32	19	37	25	21	16
48	5	8	8	78	9	11	21	186	2	5	10	54	1	7	9	114	0	5	10	84
49	7	16	7	69	68	37	34	86	8	7	10	46	22	27	23	59	9	17	14	59
50	86	8	4	1	203	12	8	3	57	7	6	1	122	5	4	0	85	8	5	1
51	22	13	15	49	49	34	37	106	11	11	16	33	19	29	18	65	14	18	16	51
52	5	8	11	74	14	23	18	168	7	9	2	53	3	18	18	92	2	12	10	75
53	9	15	14	61	5	24	13	185	3	8	10	50	2	13	12	103	6	13	12	68
54	72	9	11	7	143	28	38	18	55	10	5	1	80	20	21	9	66	14	14	4
55	68	12	10	8	143	22	35	26	47	10	10	4	77	19	20	14	68	9	18	4
56	22	16	19	42	84	33	45	65	15	13	16	27	49	33	20	29	33	21	24	21
57	2	15	3	79	10	21	14	182	3	8	4	56	1	12	14	104	1	9	11	78
58	45	17	15	22	63	35	51	78	24	20	18	9	34	23	28	45	22	35	14	28
59	17	10	6	66	83	36	37	71	8	6	13	44	38	26	15	51	13	18	20	47
60	8	14	16	61	46	39	48	91	6	10	14	40	20	23	25	63	15	16	15	52
61	1	1	0	95	5	2	6	213	0	1	2	68	1	4	4	119	0	0	0	97
62	55	15	13	16	118	28	43	38	32	11	13	15	56	28	34	13	43	24	18	14
63	31	15	9	44	98	32	46	50	13	13	18	26	39	32	19	40	22	20	23	33
64	32	16	16	35	68	43	43	73	21	19	16	15	31	30	34	35	29	23	26	21
65	86	6	6	0	211	6	8	2	70	0	1	0	122	7	2	0	87	6	4	2
66	46	19	15	19	83	26	44	74	35	16	8	11	40	24	35	31	28	26	18	26
67	58	13	18	9	152	26	33	16	36	11	13	11	67	28	25	11	48	19	20	12
68	73	12	10	3	123	23	36	44	46	13	7	4	63	23	25	20	52	21	12	14
69	22	7	13	56	91	24	35	77	12	13	16	30	39	24	24	43	24	20	21	34
70	44	16	13	25	121	28	32	41	30	10	18	12	63	27	25	16	45	17	20	16
71	4	13	10	72	3	14	7	203	0	9	11	50	1	9	7	113	3	8	7	79
72	36	18	19	25	50	34	33	110	23	20	11	17	17	31	31	51	26	21	21	31
73	5	13	10	71	11	25	36	154	4	7	9	51	5	22	16	88	5	6	12	76
74	62	18	12	7	155	20	18	33	42	13	10	5	91	17	15	8	59	21	13	6
75	57	17	11	14	127	34	37	28	45	11	10	5	62	26	30	12	48	22	21	8
76	89	7	2	0	207	9	10	0	61	5	5	0	116	8	3	3	85	6	8	0
77	73	10	8	8	128	29	43	25	42	15	10	2	65	33	24	9	51	23	16	7
78	51	11	23	13	122	45	32	25	38	15	9	9	80	15	26	10	55	16	20	5
79	57	12	16	14	199	11	12	4	33	12	12	13	107	14	9	1	64	13	16	6
80	34	22	10	33	31	31	35	130	17	21	12	20	14	19	25	73	14	25	21	39
81	17	20	14	48	48	30	47	102	13	7	17	34	21	20	28	62	8	19	27	45
82	10	18	11	59	43	29	44	108	7	17	10	36	17	14	29	70	16	11	16	53
83	70	11	10	8	206	2	14	4	56	8	3	3	123	4	3	1	80	8	8	2
84	22	14	19	44	39	39	40	109	9	11	19	32	12	26	30	63	10	19	19	51
85	4	4	7	84	14	17	29	167	2	8	7	54	5	13	14	99	1	5	11	82
86	21	18	15	42	62	27	42	94	21	18	19	12	23	23	33	47	19	16	24	38
87	76	9	6	6	190	11	18	8	54	5	7	5	114	9	5	2	75	11	9	2
88	11	25	7	56	23	31	29	144	11	16	18	26	8	21	20	80	5	27	16	51
89	29	13	18	39	46	43	43	95	13	21	17	20	24	18	38	51	21	29	24	25
90	2	4	4	89	3	5	2	217	2	5	8	56	2	3	7	118	0	4	5	89

Table 5. Results of fitting a simple additive genetic model to twin data on EPQ items previously estimated to have >20% common environmental variation

Item	χ^2	df	P	h^2	SE	Diff. χ^2	Previous h^2
1	3.23	4	0.52	0.53	0.06	2.50	0.20
6	7.24	4	0.12	0.35	0.11	2.64	0.00
9	8.54	4	0.07	0.44	0.07	3.98	0.30
18	3.04	4	0.55	0.54	0.10	1.03	0.23
24	5.64	4	0.23	0.58	0.07	3.56	0.13
41	3.11	4	0.54	0.38	0.09	0.84	0.11
59	8.93	4	0.06	0.63	0.06	1.58	0.38
60	3.48	4	0.48	0.35	0.07	2.52	0.00
73	4.54	4	0.34	0.29	0.10	1.43	0.00
82	5.22	4	0.27	0.47	0.07	2.07	0.13
83	1.49	4	0.83	0.59	0.10	0.61	0.31

and two Emotionality or Neuroticism. Loehlin (1965) suggested that the flavour of the items with high heritability pertained more to the individual, e.g. what he or she *brings* to the environment; while that of the two items with low heritability pertained more to the individual's *interaction* with the environment. Horn *et al.* (1976) used the CPI to create two item pools differing in heritability. They found that the factor structures of the high-genetic and low-genetic item pools differed considerably. For example, the genetic factors included Conversation Poise and Social Ease, whereas a factor emerging from the low-genetic pool was Impulse Control.

Plomin (1981) dichotomizes measures of childhood temperament into molecular (narrow, specific) and molar (broad, global), and suggests that twin resemblances are generally higher for molecular items. Items which are more molecular therefore, might be expected to reflect more common environmental variance. The separation of genetic and environmentally-influenced dimensions may not only reveal meaningful theoretical distinctions but also may provide a basis for practical intervention by identifying the domains of behavior most amenable to environmental manipulation (Buss, 1983).

As also discussed by Buss (1983) and Jones (1971), heritability might be used as a criterion for item inclusion in the construction of personality tests. By first ensuring that items to be included exceed a given magnitude of heritability, and then ensuring that the phenotypic correlations among items are due to genetic, rather than environmental influences, scales can be constructed to measure genetically influenced dimensions. The obverse procedure can be used to construct environmentally influenced dimensions. Item heritabilities can also be used to test psychological theories. It may be possible to make differential predictions from items with high heritabilities than from those with low. Assortative mating, friendship and altruism for example may be better predicted from similarity based on genetic causes than they will from similarity that is environmentally determined (Rushton, Russell and Wells, 1984). Evidence that this is so at the level of the scale score has already been provided (Rushton and Russell, 1985).

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