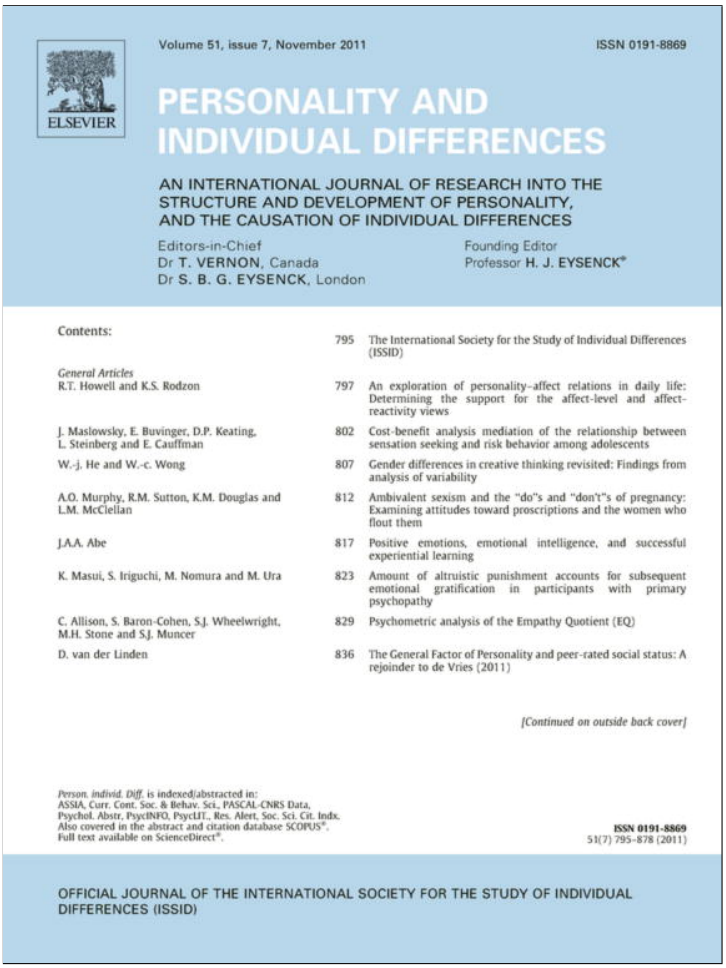

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What does a general factor of personality look like in unshared environmental variance?

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ABSTRACT

A general factor of personality (GFP) was obtained solely from unshared environment, by deriving it from the intercorrelations of monozygotic twin differences. This GFP was compared with a GFP derived from correlations reflecting all three components of variance—genes, shared environment, and unshared environment. In two large samples of adult Australian twins, for the items of two questionnaires, the two approaches gave virtually identical GFPs. However, in a sample of adolescent Australian twins, the two GFPs were correlated but distinct.

1. Introduction

Behavior genetic analyses of personality traits typically partition variance or covariance into three parts: that due to genes, that due to shared environment, and a residual—usually labeled "unshared environment." (In most applications, this last component includes the effects of measurement errors and various nonlinearities and interactions as well.) In a number of multivariate studies, factors derived from the residual component have strongly resembled factors extracted from the genetic correlations alone (e.g., Krueger, 2000; McCrae, Jang, Livesley, Riemann, & Angleitner, 2001). Similar results have been found via cluster analysis (Loehlin, 2011). One way of conceptualizing such a resemblance is the concept of *latent phenotype* (Heath, Eaves, & Martin, 1989)—the idea that factors from covariation among questionnaire items or subscales represent latent phenotypic structures, which are themselves subject to genetic or environmental influences that lie further back in the causal chain. The latent phenotypic structures may partly reflect language (*shy* means the opposite of *bold*), may partly reflect the implicit personality theories of the individuals doing the rating (of themselves or others), may be partly built into the structure of the questionnaires or other instruments being used, and so on—and of course these explanations can overlap.

In the present paper, we will look at the general factor of personality (GFP) from this perspective. The existence of a general factor of personality (GFP) was proposed by Musek (2007), and it has been suggested by Rushton, Bons, and Hur (2008) that a GFP might reflect genetic selection for social effectiveness during human evolution. We will compare two ways of arriving at a GFP: one from an analysis based on unshared environment alone, and one from an analysis based on all three sources combined: genes, shared environment, and unshared environment. If the GFP is a "latent phenotype" in the strong sense, the two approaches mentioned should yield essentially the same result. If instead the GFP reflects a history of genetic selection for social effectiveness overlaid by various linguistic, cultural, and measurement factors such as word meanings, implicit personality theories, and response biases, GFPs obtained in the two ways may differ.

We will carry out this analysis using data from two large samples of adult Australian twins. Questionnaires that the twins filled out by mail included brief versions of two personality inventories, those of Eysenck, Eysenck, and Barrett (1985) and Cloninger, Przybeck, and Svrakic (1991). GFPs from the items of each questionnaire will be obtained in each of the two ways mentioned, and the results of the two approaches compared. The Eysenck and Cloninger questionnaires cover aspects of personality that are partly overlapping but partly distinctive (Heath, Cloninger, & Martin, 1994)—the latter aspect makes generalization across the two questionnaires worth examining.

It should be emphasized that this study does not constitute an exhaustive examination of the GFP. A number of recent studies, many in the context of examining higher-order factors of the so-called Big Five, have addressed this issue, examining such matters as generalizability of self- to peer ratings (e.g., Biesanz & West,

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2004; DeYoung, 2006; Riemann & Kandler, 2010), deriving a GFP from items, scales, or facets (e.g., Ashton, Lee, Goldberg, & de Vries, 2009; Jang, Livesley, Angleitner, Reimann, & Vernon, 2002; Loehlin, in press), taking into account variables such as social desirability and self-esteem (e.g., Bäckstrom, Björklünd, & Larsson, 2009; Erdle, Gosling, & Potter, 2009), estimating the relative contribution of additive and non-additive genetic variance to a GFP (Loehlin & Martin, 2011), etc.. Rather, the present study asks simply whether a GFP derived entirely from unshared environmental sources (MZ twin differences) differs in any important ways from one derived in the usual way from scores reflecting all three sources of variance (i.e., the scores of individuals).

A qualification should be added: A GFP derived from MZ twin differences will be diluted by random errors of measurement and random errors of development, including stochastic epigenetic events, but this should not affect its structure, except quantitatively (e.g., in the size of correlations). The direct effects of genes and of shared environment are excluded from MZ differences, as are most gene-environment correlations and many gene-environment interactions, but some of the latter will remain: if the same genotype, that of both MZ twins, reacts differently to aspects of the environment that differ for the two twins, this can contribute to the differences between them.

A word should also be said about the choice of individuals who will serve as a source for extracting the full GFP. We will use for this purpose the DZ twins from the Australian sample. This is a group of individuals who have been selected in the same way and who have responded to the same questionnaires as the MZs that yield the pair differences. Because the twins of a DZ pair are not independent, the effective N for this group should be taken as somewhat below the number of individuals and somewhat above the number of pairs: probably closer to the number of individuals, since the DZ twin correlations are quite modest—.16 and .18 for the GFP for DZs in the two adult samples (Loehlin & Martin, 2011).

Thus the present paper addresses the question of the latent phenotype status of the GFP in a novel way. What does a GFP extracted wholly from environmentally-based variation look like? Is it distinguishable from a GFP derived in the ordinary manner, with (if Rushton is correct) a substantial genetic core? We do this by extracting GFPs from MZ twin differences and from DZ individuals, and comparing the two across two questionnaires.

Finally we will test the generalizability of our results by carrying out the same analysis with adolescent Australian twins. They are a somewhat smaller sample, with only one questionnaire (a junior version of Eysenck's), but they will serve to give some indication of the breadth of applicability of the main results.

2. Method

2.1. Samples

Two large samples of adult twins were available from the Australian studies. One consisted of twins of a range of ages (24–88) who filled out a 16-page mail questionnaire in 1988 as a follow-up to an earlier 1980 study. The other consisted of twins who had been too young to participate in the 1980 study, but who filled out a similar questionnaire in 1989, at ages from 17 to 29. We will refer to the two respectively as the Adult and Young Adult samples. Both the questionnaires contained, among a variety of other items, brief versions of Eysenck and Cloninger personality questionnaires mentioned above. The number of individuals completing both questionnaires was 5655–5680 for the Adult and 3500–3533 for the Young Adult sample. The numbers of MZ pairs and DZ individuals involved in various analyses were in the range 710 to 3007, and are given in the footnotes of the tables. A third sample consisted of adolescent Australian twins who were tested in person at ages 12, 14, and 16. The test battery included the Junior Eysenck Personality Questionnaire (JEPQ), which was completed at least once by 1417 individuals, comprising 411 MZ pairs and 595 DZ individuals.

2.2. Questionnaires

The Adult twin sample received a 55-item version of the Eysenck Personality Questionnaire (EPQ; Eysenck et al., 1985) in which the 48 items of the EPQ-R-S (12 items each for Extraversion, Neuroticism, Psychoticism, and Social Desirability) were augmented with 7 impulsiveness items (since the 12 Extraversion items of the EPQ-R-S only probe sociability). They also completed a 54-item version of the Cloninger Tridimensional Personality Questionnaire—18 items each for the dimensions of Harm Avoidance, Novelty Seeking, and Reward Dependence (TPQ; Cloninger et al., 1991). The Young Adult sample received a 67-item version of the EPQ (which included the 55 items in the questionnaire for the Adult sample). Both samples received the same 54 TPQ items, although in somewhat different order. In the examples in this paper, the "first 20 items" refers to the items that are first in the Adult questionnaire. The Adolescent sample completed an 81-item version of the JEPQ (Eysenck & Eysenck, 1975). Many of them took it more than once at different ages. For these, the mean response of the individual to each item was calculated and used in subsequent analyses.

2.3. Analyses

A general factor of personality (GFP) was extracted from each set of Eysenck or Cloninger items, using all available items (i.e., from 54 to 81 items in the various samples). A GFP was obtained as the first principal component of the relevant item set. Two GFPs were obtained in each instance, one based on the within-pair differences of MZ pairs, and the other on twins from DZ pairs considered as individuals. For the first, a signed difference score was obtained for each twin pair for each item, and a first principal component obtained from the intercorrelation of these pair differences across the MZ pairs. For the second, a principal component was calculated from the intercorrelation of item scores across the set of DZ individuals. For ease of interpretation, obtained GFPs were reflected as necessary to make them consistent in sign across analyses.

3. Results

The main focus in this paper is in the degree of similarity between the GFPs derived from MZ differences and from DZ individuals in the various item sets. The former should chiefly reflect unshared environmental variance, the latter, all sources—the genes, shared environment, and unshared environment.

The tables show the degree of similarity of GFPs derived in the two ways from the Eysenck and Cloninger item sets in the adult samples. In each table is given, for illustrative purposes, the factor loadings on the GFP of the first 20 items. Also given is the correlation over the full set of items between the loadings of the GFP based solely on unshared environment (MZ differences), and that based on all three genetic and environmental components (DZ individuals). For economy of space, full items are not given in the tables, but a few words characterizing each are provided.

Table 1 shows GFPs based on the Eysenck items, obtained via both approaches in the two adult samples. For both samples, the GFPs based on MZ differences and DZ individuals were virtually

Table 1
GFP factor loadings on the first 20 Eysenck items for MZ differences and DZ individuals in two samples, and correlations of loadings over all items.

Item	Adult twins		Young Adult twins	
	MZ diffs	DZ indiv	MZ diffs	DZ indiv
Mood up and down	−.38	−.30	−.32	−.40
Care what people think	−.27	−.26	−.40	−.37
Talkative	.32	.50	.34	.37
Keep promises	.15	−.00	.09	.09
Debt would worry	−.14	−.23	−.26	−.21
Miserable for no reason	−.32	−.33	−.32	−.40
Rather lively	.44	.55	.46	.39
Like others to fear me	−.06	−.03	−.02	−.12
Have been greedy	−.04	.08	−.14	−.03
Think before acting	.04	−.07	−.05	.01
Let self go at party	.44	.57	.40	.45
Irritable	−.36	−.25	−.36	−.36
Would try risky drugs	.03	.03	.08	.05
Enjoy new people	.37	.46	.33	.39
Blamed someone else	−.17	−.00	−.18	−.07
Prefer go own way	−.01	.12	.08	.06
All my habits good	.11	.00	.08	.06
Sometimes act rashly	−.08	.16	.01	−.05
Feelings easily hurt	−.37	−.38	−.39	−.52
Keep in background	−.54	−.67	−.50	−.54
Correlation over all items	.963		.973	

Note: Number of items: 55 for Adult and 67 for Young Adult twins. Sample sizes: 1338 MZ pairs and 3007 DZ individuals for Adult sample; 715 MZ pairs and 2103 DZ individuals for Young Adult sample.

identical, as evidenced by the correlations of .963 and .973 between factor loadings shown at the bottom of the table. Inspection of the items suggests that in all four cases the GFP contrasts a lively, confident sociability with moodiness, shyness, and sensitivity. The consistently high positive loadings are on *Talkative*, *Rather lively*, *Let self go at party*, and *Enjoy new people*; among the consistently negative loadings are *Keep in background*, *Feelings easily hurt*, *Irritable*, and *Miserable for no reason*. Note that this is not simply a good-bad dimension: such items as *Keep promises*, *Think before acting*, and *Would try risky drugs* have very modest loadings.

Table 2
GFP factor loadings on first 20 Cloninger items for MZ differences and DZ individuals in two samples, and correlations of loadings over all items.

Item	Adult twins		Young Adult twins	
	MZ diffs	DZ indiv	MZ diffs	DZ indiv
Confident when others worried	.39	.41	.38	.63
Try new things for fun	.20	.34	.33	.37
Discuss feelings with friends	.36	.34	.30	.34
Look for excitement	.18	.32	.32	.39
Worried about future	−.38	−.43	−.39	−.43
Relaxed when others fearful	.30	.35	.39	.38
Seldom tell private thoughts	−.39	−.40	−.36	−.30
Stop because of worries	−.37	−.40	−.27	−.38
Do things my own way	.05	.08	.10	.14
Worried with unfamiliar	−.45	−.57	−.52	−.61
Worried when others not very	−.55	−.64	−.54	−.62
Act on current feelings	−.01	.01	.07	.04
Worried when others not	−.54	−.59	−.47	−.57
Break rules	−.03	.14	.10	.12
Do not care if others like me	.04	−.00	.09	.17
Calm in danger	.20	.25	.27	.34
Easy to get my sympathy	.20	.15	.19	.22
Reserved and controlled	−.17	−.20	−.07	.07
Shy meeting strangers	−.54	−.62	−.52	−.61
Moved by sentimental appeals	−.06	−.07	−.09	−.05
Correlation over 54 items	.978		.988	

Note: Sample sizes: 1324 MZ pairs and 3007 DZ individuals for Adult sample; 710 MZ pairs and 2080 DZ individuals for Young Adult sample.

Table 3
GFP factor loadings on first 20 JEPQ items for adolescent twins for MZ differences and DZ individuals, and correlation of loadings over all items.

Item	Adolescent twins	
	MZ diffs	DZ indiv
Like plenty of excitement	.09	.40
Moody	−.35	−.26
Enjoy hurting people	−.10	−.01
Have been greedy	−.30	.05
Have quick answers	.03	.26
Easily bored	−.43	−.13
Enjoy risky practical jokes	−.26	.10
Promptly do as I'm told	.10	−.18
Rather be alone	−.27	−.40
Thoughts keep me awake	−.30	−.20
Have broken rules at school	−.14	.35
Like others to fear me	−.09	−.01
Lively	.10	.55
Lots of things annoy me	−.44	−.27
Would like dissecting animals	.01	.19
Have taken item of another's	−.18	.17
Have lots of friends	.08	.45
Just miserable for no reason	−.54	−.30
Sometimes like tease animals	−.15	.09
Have pretended not to hear call	−.33	.00
Correlation over all 81 items	.615	

Note: Sample sizes: 411 MZ pairs, 595 DZ individuals.

Table 2 shows similar results for the Cloninger items. The correlations between factor loadings derived solely from unshared environment or from all genetic and environmental sources again approached unity. They were .978 and .988 in the two adult samples. Again, the main contrast appears to be between the confident, relaxed, and sociable individual and the shy and worried one. And again it is not simply a good-bad dimension: items like *Do things my own way*, *Break rules*, and *Do not care if others like me* have quite modest loadings.

Table 3 tells a somewhat different story for the adolescent twins. The two GPFs were positively correlated, at .615, but well short of the near-unity correlations seen for the adults. The GFP for the DZ individuals emphasizes the confident sociality of the adult GFPs, with its highest positive loadings on *Lively*, *Have lots of friends*, and *Like plenty of excitement*, and its highest negative loading on *Rather be alone*. The adolescent GFP from the MZ pair differences, however, appears to be focused on negative emotions—*Just miserable for no reason*, *Lots of things annoy me*, *Easily bored*. The correlation between factors appears to be due to the fact that the negative emotion items also tended to appear with negative loadings on the DZ-based GFP, although with smaller ones.

4. Discussion

For two questionnaires in two adult samples, a general factor of personality derived solely from unshared environment proved to be virtually identical to one derived from all three genetic and environmental sources. This suggests that the nature of the GFP, at least as observed in questionnaire data, is not a function of the genes involved, but is inherent in the phenotype. In a broader sense, this is consistent with the idea variously expressed as *latent phenotypes* (Heath et al., 1989), the *psychometric factors model* (McArdle & Goldsmith, 1990), and the *common pathway model* (Kendler, Heath, Martin, & Eaves, 1987), namely, that the immediate structure of personality reflects underlying phenotypic factors which in turn are subject to whatever genetic and environmental influences may be involved. The present results suggest that such a view characterizes the GFP as well: that personality structure is simply personality structure, that personality items go together

in the ways they do because of their surface meanings and/or raters' implicit personality theories, not because of the causes that ultimately underlie them.

A possible alternative view might be that the GFP comes solely from the unshared environmental variance, and its appearance in the total variance is a result of this. However, another analysis of the Australian data (Loehlin, 2011) based on item clustering, found several clusters emerging from items grouped on the basis of genetic correlations to be similar to ones grouped on the basis of correlations in the unshared environment, consistent with an interpretation involving latent phenotypes.

But what of the adolescent GFPs? The one based on unshared environment, although correlated with the one based on all sources, differed appreciably from it, with less emphasis on sociality and adventurousness, and more on negative emotions. Although the particular items in the questionnaires differ, the GFP derived from the adolescent DZ individuals resembles the positive end of the GFPs derived from adults in Tables 1 and 2—lively, sociable—whereas that derived solely from unshared environment resembles the negative end—moody, irritable, miserable for no reason. In Loehlin and Martin (2011), overall GFPs for adolescent twins showed a number of differences from GFPs for adults. That for adolescents had an emphasis on boredom and annoyance versus exemplary behavior. Adolescent personality may just not be as coherent as adult personality—although one would like to see such a conclusion based on larger samples and a wider range of ages.

Finally, what, if anything, do the present results say about Rushton's theory of a genetically-evolved GFP? First, at least as far as the adults are concerned, the question of origins is moot: GFPs derived solely from unshared environment were virtually identical to ones derived from the genes plus shared and unshared environment, suggesting that the observed GFP reflects expressed personality, not its genetic or environmental origins. The GFPs obtained at adolescence, however, suggest that in the process of the personality settling down into its adult form there may be some distinctive features in the role played by unshared environment, in a greater emphasis on negative emotions and fluctuating moods. In young twins living together, differences in mood and emotion may well be more salient than in adult twins mostly living apart. Moreover, a greater emotional instability among adolescents than among adults is quite plausible. As mentioned previously, however, it would be desirable to have more data on this point—ideally, longitudinal data—before drawing firm conclusions.

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