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# A General Factor of Personality From Multitrait–Multimethod Data and Cross–National Twins

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In three studies, a General Factor of Personality (GFP) was found to occupy the apex of the hierarchical structure. In Study 1, a GFP emerged independent of method variance and accounted for 54% of the reliable variance in a multitrait–multimethod assessment of 391 Italian high school students that used self-, teacher-, and parent-ratings on the Big Five Questionnaire — Children. In Study 2, a GFP was found in the seven dimensions of Cloninger’s Temperament and Character Inventory as well as the Big Five of the NEO PI-R, with the GFP<sub>TCI</sub> correlating  $r = .72$  with the GFP<sub>NEO</sub>. These results indicate that the GFP is practically the same in both test batteries, and its existence does not depend on being extracted using the Big Five model. The GFP accounted for 22% of the total variance in these trait measures, which were assessed in 651 pairs of 14- to 30-year-old Japanese twins. In Study 3, a GFP accounted for 32% of the total variance in nine scales derived from the NEO PI-R, the Humor Styles Questionnaire, and the Trait Emotional Intelligence Questionnaire assessed in 386 pairs of 18- to 74-year-old Canadian and U.S. twins. The GFP was found to be 50% heritable with high scores indicating openness, conscientiousness, sociability, agreeableness, emotional stability, good humor and emotional intelligence. The possible evolutionary origins of the GFP are discussed.

**Keywords:** Big One, Big Five, TEIQue, heritability, general factor of personality

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A recent observation is that a General Factor of Personality (GFP) occupies the apex of the personality hierarchy in the same way that *g*, the general factor of mental ability, occupies the apex in the organization of cognitive abilities. Individuals high on the GFP are characterized as altruistic, emotionally stable, agreeable, conscientious, extraverted, intellectually open, mentally tough, and emotionally intelligent; further, they express

a sense of wellbeing, satisfaction with life, and high self-esteem (Musek, 2007; Rushton et al., 2008; Rushton & Irwing, 2008, 2009; Veselka et al., 2009). The GFP is conjectured to have evolved as a result of natural selection for socially desirable behavior.

The concept of a general factor of personality, like the general factor of cognitive ability, can be traced back to Sir Francis Galton (1822–1911) who (1887) grouped 15 desirable adjectives and 46 undesirable ones along a single dimension of ‘good and bad temper’ in an analysis of ratings from 1,981 family members across four generations. Although Galton identified three times as many adjectives denoting bad temper as good, he found a bell-shaped distribution with neutral scores in the middle in the ratio of 2:1 to both extremes. He also found temper ran in families. When both parents were recorded as good-tempered, 30% of the children were good-tempered and 10% bad-tempered, with the remaining 60% being neutral. When both parents were recorded as bad-tempered, 4% of the children were good-tempered and 52% were bad-tempered (the remainder neutral). Conversely, 26% of the parents, uncles, and aunts of good-tempered brothers and sisters were good-tempered and 18% bad-tempered, whereas 29% of the parents, uncles, and aunts of bad-tempered brothers and sisters were bad-tempered and 18% good-tempered.

The genetics and evolution of the GFP were discussed by Rushton et al. (2008), who reported a GFP that accounted for 56% of the reliable variance in measures of altruism, the Big Five factors, and the EAS temperament traits of Emotional Stability, Activity, and Sociability. The results were robust across three diverse samples — 214 university students

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from Canada, 322 pairs of adult monozygotic (MZ) and dizygotic (DZ) twins from the UK, and 575 pairs of 2- to 9-year-old twins from South Korea. The twin data showed the GFP had emerged by 2 to 3 years of age, with 50% of the variance attributable to non-additive genetic influence (dominance and epistasis) and 50% to nonshared environmental influence.

A genetic and evolutionary basis for a GFP was proposed by Rushton (1985, 1990) who hypothesized that ‘one basic dimension —  $K$  — underlies much of the field of personality’ (1985, p. 445). Rushton’s explanation for the GFP built on E. O. Wilson’s (1975) theory of  $r$ - $K$  life-histories, which explains how animals colonize islands and reach population equilibrium. Individuals and species genetically inclined to  $r$ -reproductive strategies produce more offspring but provide less parental care, while those inclined to  $K$ -reproductive strategies produce fewer offspring but provide greater parental care. Rushton (1985) dubbed his formulation, ‘differential  $K$  theory’ and predicted that diverse personality traits, maturational speed, brain size, intelligence, attachment styles, longevity, sexuality, and fecundity would correlate together as a suite of characteristics genetically organized to meet the trials of life — survival, growth, and reproduction. Unlike conventional personality psychology, life-history theory predicts hierarchically organized traits, culminating in a single, harmonized super-factor. Traits need to be coordinated and work together, not act independently or in opposition to each other.

Research has confirmed many predictions from differential  $K$  theory (Bogaert & Rushton, 1989; Figueredo et al., 2004, 2007; Rowe & Flannery, 1994). For example, among university students, Bogaert and Rushton (1989) found correlations between self-reported delinquency, sex guilt, mating effort (e.g., number of sex partners), general intelligence, and an aggregate of items assessing family size, maturational speed, longevity, and altruism. Although the average correlation between single indices of  $K$  was low, aggregate measures were predictive of a general factor on which single items loaded an average of .31. The results held true when three separate measures of family background were statistically controlled. In a twin sample, Figueredo et al. (2004) found a substantially heritable dimension they termed ‘Super- $K$ ’, which comprised three lower-order (also heritable) factors (a general personality factor, a ‘co-vitality’ health factor, and a lower-order  $K$  factor). Subsequently, Figueredo et al. (2007) replicated the findings using a sample of 2,095 non-twin parents who, by middle age, had chosen their life niches to marry (or not), to bear and raise offspring (or not), and to create social networks. In both studies, Figueredo et al. controlled for ‘social privilege’ by regressing out level of education, race, and family income and found it accounted for less than 10% of the variance and did not change the pattern of factor loadings.

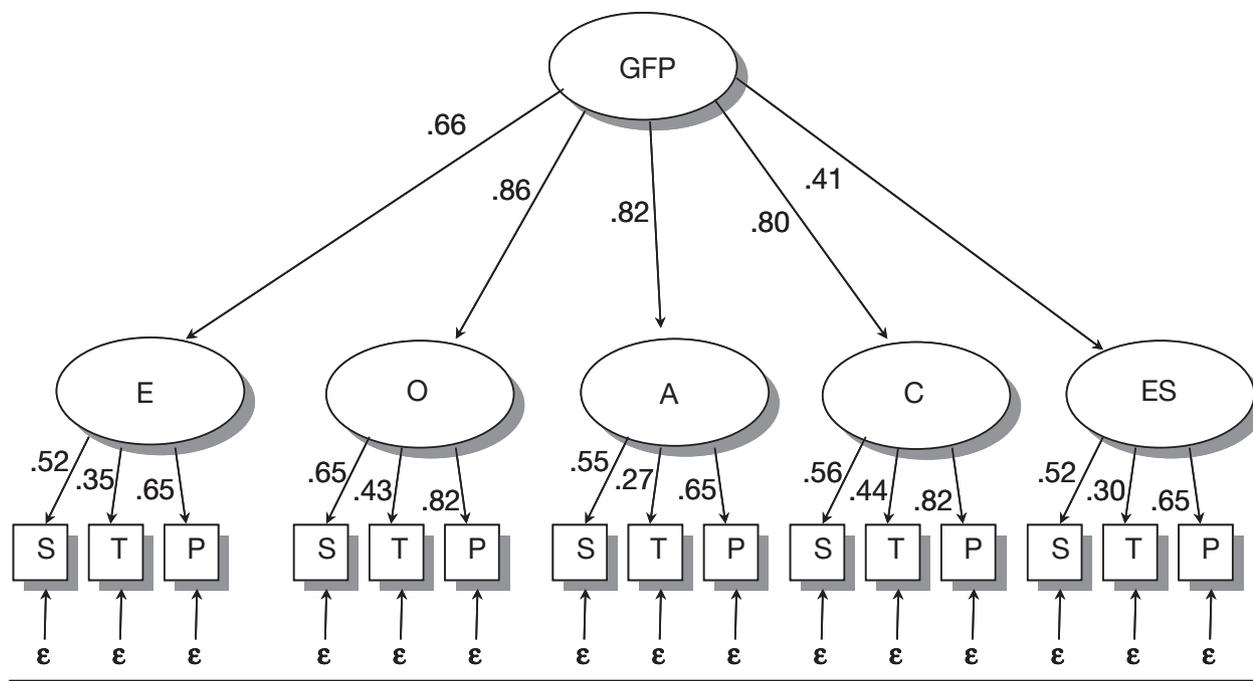
The main empirical impetus for identifying the GFP has come from the often manifested positive

manifold among personality scales. For example, the Big Five factors are not orthogonal and typically correlate with each other. Thus, Digman’s (1997) examination of 14 studies of inter-scale correlations in the Big Five found an average correlation of  $r = .26$ , and obtained two reliable higher order factors: Alpha (Agreeableness, Conscientiousness, Emotional Stability) and Beta (Extraversion, Openness), which he associated with socialization processes and personal growth, respectively.

Rushton and Irwing (2008) found remarkable evidence for a GFP in two meta-analyses of Big Five correlations using structural equation modeling (SEM). In Study 1, a GFP explained 45% of the reliable variance in a model that went from the Big Five to the Big Two and then to the Big One in the 14 sets of inter-scale correlations ( $N = 4,496$ ) assembled by Digman (1997) to establish the Big Two. Higher order Alpha was defined by Conscientiousness, Emotional Stability, and Agreeableness, with loadings of from .61 to .70, while Beta was defined by Openness and Extraversion, with loadings of .55 and .77. In turn, the GFP was defined by Alpha and Beta with loadings of .67. In Study 2, this model was cross-validated and the GFP found to explain 44% of the variance using data from a published meta-analysis of four alternative measures of the Big Five ( $N = 4,000$ ) by Mount et al., (2005).

As Rushton et al. (2008) discussed based on the results of their twin studies, the finding that 50% of the variance in the GFP, as well as in lower-order traits, is attributable to nonadditive genetic influence implies that a trait has been under recent natural selection. This is expected for a Darwinian fitness character, that is, one that leads to greater reproductive success (Falconer, 1989; Fisher, 1954; Penke et al., 2007). Rushton et al. suggested that individuals at the positive pole of the GFP possessed more cooperative and prosocial personalities and hence, through social and sexual selection, left more progeny than those at the negative pole, since people prefer as mates, fellow workers, and leaders, those who are agreeable and emotionally stable. This was a view initially proposed by Darwin (1871), who suggested that natural selection acted directionally to endow contemporary humans with more cooperative and less contentious personalities than their archaic ancestors, or nearest living relatives, the chimpanzees (see also Miller, 2007).

In this article, we examine the GFP in re-analyses of three existing data sets. In Study 1, we examine data from 391 13- to 14-year-olds on the Big Five Questionnaire — Children to test whether the GFP exists independent of method variance in a multitrait–multimethod (MTMM) assessment of self-, teacher-, and parent-ratings. In Study 2, we analyze data from 651 pairs of 14- to 30-year-old Japanese twins to test whether a GFP can be extracted from the seven dimensions of Cloninger’s (1987) Temperament and Character Inventory (TCI) and the Big Five NEO PI-R, and then examine the relation between the GFP<sub>TCI</sub> and GFP<sub>NEO</sub> and of both of these with measures of intelligence. In



**Figure 1**

A multitrait-multimethod model of the structural hierarchy of the GFP from self-report, teacher, and parent ratings from the Big Five going directly to the GFP based on a re-analysis of Barbaranelli et al.'s (2008) data.

Note: S = Self report, T = Teacher report, P = Parent report. Uniquenesses of the same informant are correlated.

E = Extraversion, O = Openness, A = Agreeableness, C = Conscientiousness, ES = Emotional Stability, GFP = General Factor of Personality.

Study 3, we analyze data from 386 pairs of 18- to 74-year-old Canadian and U.S. twins to test the relation of the GFP to measures of trait emotional intelligence and humor style. In the twin studies, we examine whether the genetic influences on the GFP are non-additive (D) as well as additive (A).

### Study 1: A Multi-Trait Multi-Method Study of Italian High School Students

The data to be reanalyzed came from a study on 391 13- to 14-year-olds (205 boys, 186 girls) enrolled in a junior high school in a residential community near Rome, Italy (Barbaranelli et al., 2008). Assessments had been carried out using the Big Five Questionnaire — Children and self-, teacher-, and parent-ratings (BFQ-C; Barbaranelli et al., 2003). The study provided evidence for the convergent and discriminant validity of the Big Five factors using Campbell and Fiske's (1959) MTMM procedure. It conceptually replicated and extended previous studies (Barbaranelli & Caprara, 2000; Biesanz & West, 2004).

#### Method

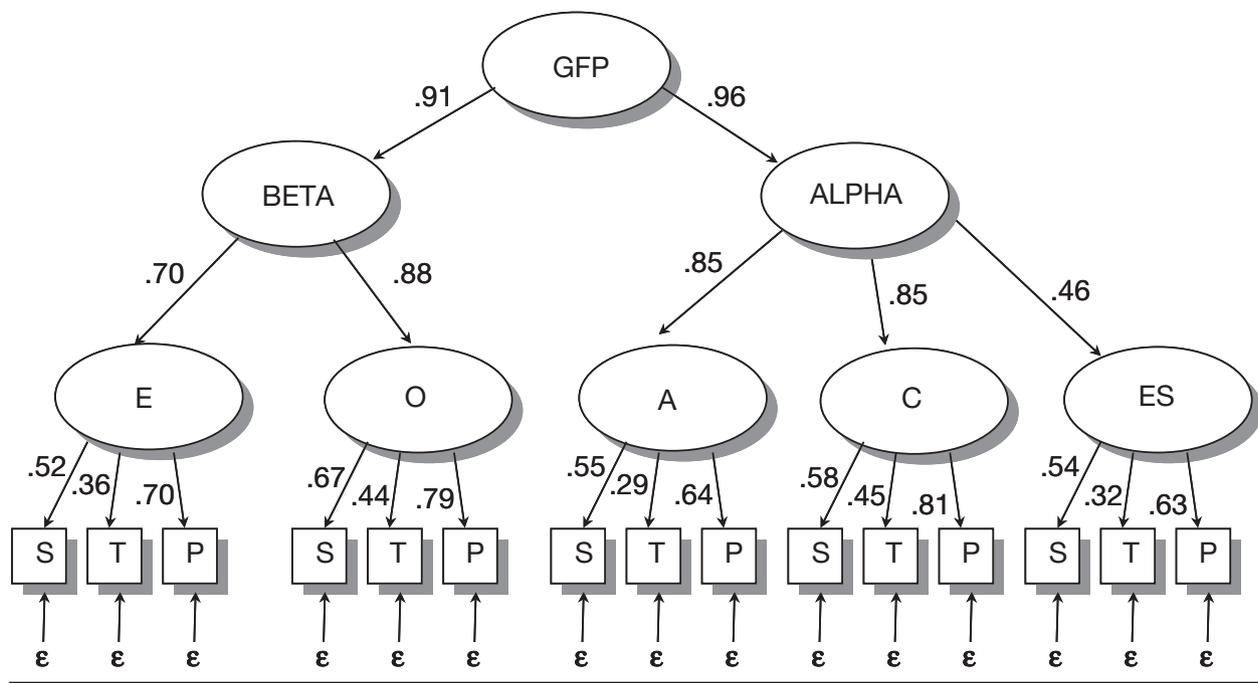
The BFQ-C contains 65-items, 13 for each of the five factors: *Energy/Extraversion* (activity, enthusiasm, assertiveness and self-confidence); *Agreeableness* (sensitivity toward others and their needs); *Conscientiousness* (dependability, orderliness, precision, and the fulfilling of commitments); *Emotional Instability* (feelings of anxiety, depression, discontent, and anger); and

*Intellect/Openness* (cultural interests and fantasy/creativity). Ratings are on 5-point scales (from 1 = *Almost never* to 5 = *Almost always*). The students were administered the self-report BFQ-C in their classrooms during school hours. The third-person phrased version of the BFQ-C was administered to teachers and parents. Teachers were asked to rate students in their class (about 15 for each teacher) within 30 days. Parents were asked to rate their daughter/son and return the questionnaire within 30 days.

Barbaranelli et al. (2008) reported that the Cronbach alphas ranged from .82 to .95. Confirmatory factor analytic models were tested analyzing the covariance matrix of the 15 trait-method units derived by crossing the five traits with the three different methods (i.e., self-, parent-, and teacher-ratings). Among all models tested, the so-called correlated uniqueness model resulted in the best fit and provided an admissible solution for all parameters. Convergent validity was clear from the factor loadings, which ranged from .31 to .80, although substantial error variance was also detected. Discriminant validity was achieved only in a 'weak' sense because the correlations among the latent trait factors were generally high and positive (mean  $r = .37$ ; range = .05 to .70, reverse keying Emotional Instability).

#### Results and Discussion

Maximum likelihood confirmatory factor analysis was used to test whether the GFP exists independent of method variance. The first model posited a second



**Figure 2**

A multitrait-multimethod model of the structural hierarchy of the GFP from self-report, teacher, and parent ratings from the Big Five going to the Big Two and then to the Big One from a re-analysis of Barbaranelli et al.'s (2008) data.

Note: S = Self report, T = Teacher report, P = Parent report. Uniquenesses of the same informant are correlated.

E = Extraversion, O = Openness, A = Agreeableness, C = Conscientiousness, ES = Emotional Stability, GFP = General Factor of Personality.

order GFP underlying the five first-order trait factors derived from the MTMM model. Figure 1 presents the model, which shows a substantial fit to the empirical data,  $\chi^2(56, N = 385) = 144, p < .05$ ; NNFI = .94; CFI = .97; SRMR = .06; RMSEA = .06 [.05, .08]. Although the Chi square fit index should be non-significant, its magnitude is partly a function of sample size so that, with moderate-to-large sample sizes such as the one in this study ( $N = 391$ ), it may be more useful to look at other fit indicators that in this case are good. In the fitted model, the factor loadings of the primary factors on the second-order GFP were all high and statistically significant: Openness, .86; Conscientiousness, .80; Extraversion, .66; Agreeableness, .82; and Emotional Stability, .41. Since the GFP does not affect directly the 15 observed trait-method units, an effects decomposition procedure found the GFP accounted for 54% of the reliable variance (18% of the total variance).

We further explored the GFP hypothesis through a 3rd order confirmatory model in which the Big Two Digman factors of Alpha (Stability) and Beta (Plasticity) were posited as mediating the influence of the GFP to the five primary factors. Figure 2 presents the fitted model, which showed a slightly better fit to the empirical data than the model in Figure 1,  $\chi^2(55, N = 385) = 137, P < .05$ , NNFI = .95; CFI = .97; SRMR = .06; RMSEA = .06 [.49, .08]. Alpha was loaded highly and significantly by Agreeableness, .85; Conscientiousness, .85; and Emotional Stability, .46; while Beta was loaded highly and significantly by

Extraversion, .70; and Openness, .88. The two second-order factors, in their turn, showed high and significant loadings on the third-order GFP: .96 for Alpha and .91 for Beta. As in the second order model, using effects decomposition, the GFP again accounted for 54% of the reliable variance.

The finding of a GFP in this study stands in contrast to three earlier failures to find the effect (Biesanz & West, 2004; DeYoung, 2006; McCrae et al., 2008). Although Biesanz and West's (2004) non-finding was due to the low interrater agreement in that study (DeYoung, 2006), the present mean interrater agreement of .34 is similar to that found by DeYoung (2006) and McCrae et al. (2008), so that is not the source of our high correlations among the latent traits (mean  $r = .46$ ). One likely possibility is that the sample of teenagers studied here were much better known to their raters in the school context of evaluation (by peers, parents, and teachers) than is typically the case, such as in DeYoung's (2006) community samples where individual adults were rated by neighbors and even children as well as by family members.

### Study 2: A Study of Japanese Twins on the TCI and NEO PI-R

The data for re-analysis came from a study of more than 651 pairs of 14- to 30-year-old Japanese twins from the Keio Twin Project, Tokyo, Japan (Shikishima et al., 2006). The twins had completed an extensively validated Japanese-language translation of the NEO

PI-R which measures the Big Five factors (Yoshimura et al., 1998) and Cloninger's Temperament and Character Inventory (TCI), which gauges the seven dimensions of Novelty Seeking, Harm Avoidance, Reward Dependence, Persistence, Self-Directedness, Cooperativeness, and Self-Transcendence (Kijima et al., 1996).

### Method

Like the already described Big Five factors, each of the seven TCI dimensions, with the sole exception of *Persistence*, is defined by facet traits which are summed to yield a total score. They are: *Novelty Seeking* (Exploratory Excitability, Impulsiveness, Extravagance, Disorderliness); *Harm Avoidance* (Anticipatory Worry, Fear of Uncertainty, Shyness, Fatigability); *Reward Dependence* (Sentimentality, Attachment, Dependence); *Self-Directedness* (Responsibility, Purposefulness, Resourcefulness, Self-Acceptance, Congruent); *Cooperativeness* (Social Acceptance, Empathy, Helpfulness, Compassion, Pure-Hearted); and *Self-Transcendence* (Self-Forgetful, Transpersonal Identification, Spiritual Acceptance).

Previously published analyses of the Japanese twin data have found that all the dimensions of the NEO PI-R and TCI have heritabilities of 40% to 50% and that the DZ twin correlations are less than half the size of the MZ twin correlations, implying nonadditive genetic variance (Shikishima et al., 2006, p. 813, Figure 1). Moreover, Ando et al. (2004) found substantial genetic overlap among the various TCI subscales and dimensions, indicating the same genes were influencing a variety of facets. Consequently, Ando et al. suggested that heritability information might be used to construct more genetically homogeneous scales.

### Results and Discussion

The GFP was extracted from both the NEO PI-R and TCI data. There were 680 twin pairs for the NEO (470 MZ and 210 DZ including 79 opposite-sex pairs) and 616 twin pairs for the TCI (433 MZ and 183 DZ including 72 opposite sex pairs). A principal factor analysis yielded a GFPneo that accounted for 22% of the total variance. The factor loadings were: Openness, .30; Conscientiousness, .58; Extraversion, .51; Agreeableness, .20; and Emotional Stability, .62. The seven TCI factors produced a GFPtci that also accounted for 22% of the total variance with factor loadings: Novelty Seeking, .13; Harm Avoidance, -.55; Reward Dependence, .41; Persistence, .46; Self-Directedness, .53; Cooperativeness, .63; and Self-Transcendence, .40. The correlation was  $r = .72$  between the factor scores on the GFPneo and those on the GFPtci, indicating a conceptual verification of the GFP in the TCI as well as in the Big Five, and that the measurement variations in the two batteries represented a very similar dimension.

In regard to the genetic analyses, the age- and sex-adjusted intraclass twin correlations for the GFPneo were: .50 for the MZ pairs and .21 for the DZ pairs; and for the GFPtci, .48 for the MZ pairs and .20 for the DZ pairs. Based on Falconer's (1989) formula  $2*(MZr - DZr)$ , the heritabilities were 58% for the GFPneo and 56% for the GFPtci. The tendency for the DZ twin correlations to be less than half those of the MZ correlations implies nonadditive genetic variance.

Model fitting is more powerful than correlational analysis because all data are assigned appropriate weights. The genetic and environmental origins of the GFP were examined, parameter estimates made, and alternative models compared using the Mx statistical package (Neale et al., 2003). Data were analyzed on the combined sample of males and females with sex and age treated as covariates. The twin correlations for the GFPneo were .50 for the MZ pairs and .21 for the DZ pairs; for the GFPtci, .44 for the MZ pairs and .17 for the DZ pairs, very similar to the values obtained using the Falconer formula.

Table 1 shows the results of the model-fitting procedures. Univariate genetic models consisted of: additive genetic effects (A), dominance genetic effects (D), shared environmental effects (C), and nonshared environmental effects (E), which included error variance. Because it is not possible to estimate D and C in the same model, two full models, that is, the ADE and ACE models were fit to the data separately. The model-fitting analyses used the raw data option in Mx (Neale et al., 2003). Mx calculates twice the negative log-likelihood ( $-2LL$ ) of the data, with a Chi square difference test to evaluate between models. In general small Chi square values from models with few free parameters lead to small Akaike Information Criterion (AIC;  $AIC = \chi^2 - 2df$ ). Typically, the model that produces the lowest AIC, represents maximum parsimony and is considered to be the best fit. Overall, the AE model provided the best (i.e., most parsimonious) fit. However, especially for the GFPtci, there is a possibility of D (nonadditive genetic component). Although the most parsimonious model is still the AE model, the full ADE model fit better than the full ACE model. Equally, for the GFPneo, the full ADE and ACE models show the same fitness as the second best model. Bivariate genetic analysis for the GFPneo and GFPtci indicates that the full AE model which assume that A and E mediate the covariance between GFPneo and GFPtci is the most parsimonious, the full ADE model fit better than the full ACE model as the second best (see Table 2). Considering this small sample size, a possibility of D cannot be rejected.

Both the GFPneo and GFPtci were found to be independent of cognitive abilities for a subsample of 130 to 200 twin pairs. No correlations were found with IQ ( $r = .11, .03, ns$ ) or with working memory ( $r = .01, .00, ns$ ), although these cognitive variables were significantly correlated with Openness in the NEO PI-R (.33 with IQ and .24 with WM).

**Table 1**

Twin Correlations and Univariate Model Fitting Results for the General Factor of Personality (GFP) Based on Data From 651 Pairs of Japanese Twins Given the NEO PI-R (NEO) and Temperament and Character Inventory (TCI)<sup>1</sup>

Measure	MZ	DZ	Model	-2LL	df	AIC	A (95% CI)	D (95% CI)	C (95% CI)	E (95% CI)
GFPneo	.50	.21	ACE*	3039.63	1351	337.64	.49 (.21 to .59)		0.01(.00-.27)	.50 (.43 to .57)
			AE**	3039.65	1352	335.64	.51 (.43 to .57)			.49 (.43 to .57)
			CE	3052.41	1352	348.41				
			ADE*	3039.65	1351	337.65	.51 (.24 to .57)	.00†		.50 (.43 to .57)
			DE	3052.49	1352	348.49				
			E	3174.68	1353	468.68				
GFPtci	.48	.20	ACE	3099.10	1298	503.10				
			AE**	3099.10	1299	501.10	.47 (.39 to .53)			.53 (.47 to .61)
			CE	3112.47	1299	514.47				
			ADE*	3098.86	1298	502.86	.40 (.11 to .53)	.07 (.00 to .36)		.53 (.47 to .61)
			DE	3106.32	1299	508.32				
			E	3207.91	1300	607.91				

Note: \*\* = the best-fit model, \* = the second best fit model.

<sup>1</sup>Only estimates in the best and the second best-fitting models are shown. A = additive genetic effects; C = shared environmental effects; D = non-additive genetic effects; E = non-shared environmental effects including besting measurement error; 2LL = -2 log likelihood.

† = 95% CI not calculable.

### Study 3: Trait Emotional Intelligence, Humor Styles, and the GFP in Canadian Twins

The data for reanalysis came from over 316 adult twin pairs aged 17 to 74 years ( $M = 24$ ,  $SD = 6$ ) residing in Canada and the United States. They had been previously studied by Vernon, Martin et al. (2008), Vernon, Petrides et al. (2008), Vernon, Villani et al. (2008), and Veselka et al. (2009). Depending on the analysis, there was always a minimum of 213 pairs of MZ twins (174 female pairs, 39 male pairs) and 103 pairs of DZ twins (95 female pairs, 8 male pairs). In addition to the NEO PI-R, most of the twins had completed the Humor Styles Questionnaire (HSQ), which has four factors: Affiliative, Self-Enhancing, Aggressive, and Self-Defeating (Martin, 2007), and the Trait Emotional Intelligence Questionnaire (TEIQue), which also has four factors: Wellbeing, Self-Control, Emotionality, and Sociability (Petrides, 2009; Petrides, Pita et al., 2007).

The previous studies had reported moderate to high heritabilities for the Big Five factors and most of the dimensions of the HSQ and TEIQue and that the phenotypic correlations between the Big Five, humor style, and trait emotional intelligence were largely based on correlated genetic factors. Additionally, Veselka et al. (2009) extracted a GFP from the Big Five traits in combination with 15 facets of emotional intelligence, with individual differences in the GFP fully accounted for by genetic and nonshared environmental factors. In the present study we also examine whether the genetic variance suggests dominance effects.

### Results and Discussion

The twin sample was divided arbitrarily into two halves — designated as ‘Twin 1’ and ‘Twin 2’, and separate principal components analysis performed on each in order to compare the results. In both samples a clear GFP emerged on the combined five factors of

**Table 2**

Cross-Twin Cross-Trait Correlations and the Parameter Estimates in the Best- and the Second Best-Fitting Bivariate Models and Their 95% CI for the General Factor of Personality (GFP) Based on Data from 651 Pairs of Japanese Twins Given the NEO PI-R (NEO) and Temperament and Character Inventory (TCI)

Cross-Twin Cross-Trait	Model	A (95% CI)		D (95% CI)		E (95% CI)		$r_g$	$r_d$	$r_e$	
		GFPtci	GFPneo	GFPtci	GFPneo	GFPtci	GFPneo				
MZ	DZ										
.44	.17	ADE*	.50 (.20 to .56)	.33 (.15 to .52)	.00 (.00 to .33)	.14 (.00 to .32)	.50 (.43 to .57)	.53 (.46 to .60)	.96 (.75 to 1.0)	.00 (.00 to .32)	.55 (.48 to .61)
		AE**	.50 (.43 to .56)	.46 (.39 to .53)	—	—	.50 (.44 to .57)	.54 (.47 to .61)	.81 (.74 to .88)	—	.55 (.48 to .61)

Note: \*\* = the best-fit model, \* = the second best fit model

A = additive genetic effects; D = nonadditive genetic effects; E = nonshared environmental effects including measurement error; 2LL = -2 log likelihood

$r_g$  = additive genetic correlation between GFPtci and GFPneo;  $r_d$  = nonadditive genetic correlation between GFPtci and GFPneo;

$r_e$  = nonshared environmental correlation.

**Table 3**

Twin Correlations and Model Fitting Results for the General Factor of Personality (GFP) Based on 316 Pairs of Canadian and US Twins Given the NEO PI-R, the Humor Styles Questionnaire (HSQ) and the Trait Emotional Intelligence Questionnaire (TEIQue)

	MZ	DZ	A (95% CI)	D (95% CI)	C (95% CI)	E (95% CI)
<b>Personality factors</b>						
Openness to experience	.65	.32		.65 (.42 to .71)		.35 (.29 to .43)
Conscientiousness	.46	.17		.47 (.25 to .56)		.53 (.44 to .63)
Extraversion	.49	.28	.43 (.07 to .57)		.06 (.00 to .38)	.51 (.43 to .61)
Agreeableness	.48	.27	.44 (.08 to .57)		.04 (.00 to .36)	.52 (.43 to .62)
Neuroticism	.58	.18		.56 (.36 to .64)		.44 (.36 to .53)
<b>Humor factors</b>						
Affiliative	.49	.28	.44 (.13 to .57)		.05 (.00 to .32)	.51 (.43 to .60)
Self-enhancing	.43	.09		.41 (.24 to .59)		.59 (.50 to .68)
Aggressive	.45	.44	.17 (.00 to .46)		.31 (.07 to .50)	.52 (.43 to .61)
Self-defeating	.37	.36	.05 (.00 to .37)		.33 (.04 to .44)	.62 (.53 to .71)
<b>TEIQue factors</b>						
Emotionality	.35	.13		.35 (.23 to .46)		.65 (.54 to .77)
Self-Control	.48	.02		.48 (.37 to .58)		.52 (.42 to .63)
Sociability	.50	.12		.50 (.40 to .59)		.50 (.41 to .60)
Wellbeing	.40	.03		.41 (.29 to .52)		.59 (.48 to .71)
GFP	.41	.05		.42 (.30 to .53)		.58 (.47 to .70)

Note: A = additive genetic effects, D = nonadditive genetic effects, C = shared environmental effects, E = nonshared environmental effects including measurement error.

the NEO PI-R, the four factors of the HSQ, and the four factors of the TEIQue. In the first sample, the GFP accounted for 33% of the total variance with loadings: Openness, .37; Conscientiousness, .59; Extraversion, .65; Agreeableness, .42; Emotional Stability, .72; Affiliative, .36; Self-Enhancing, .57; Aggressive, -.21; Self-Defeating, -.16; Wellbeing, .84; Self-Control, .70; Emotionality, .77; and Sociability, .63. The second sample showed a very similar set of results. The GFP accounted for 31% of the total variance with loadings: Openness, .40; Conscientiousness, .47; Extraversion, .61; Agreeableness, .35; Emotional Stability, .65; Affiliative, .45; Self-Enhancing, .57; Aggressive, -.18; Self-Defeating, -.18; Wellbeing, .84; Self-control, .62; Emotionality, .73; and Sociability, .69. Alternative methods of combining items and scales, or carrying out the analyses, did not appreciably alter the results.

Table 3 presents the MZ and DZ twin correlations for the 13 factors plus a global GFP score, along with the genetic and environmental parameter estimates derived from univariate behavioral genetic model-fitting. A and D represent the proportion of variance in each variable attributable to additive and nonadditive genetic effects, while C and E represent the proportion of the variance attributable to shared and nonshared environmental effects. In several cases, the inter-twin correlations for the MZ pairs were more than twice those for the DZ pairs, implying nonadditive genetic effects. Confidence intervals at 95% are given for all parameter estimates and the fact that none of these includes zero indicates that all heritability and environmental coefficients are statistically significant beyond the .05 level.

## General Discussion

The three studies reported here confirm the hypothesis that a General Factor of Personality (GFP) occupies the apex of the hierarchical structure of personality. In Study 1, a GFP emerged independent of method variance and accounted for 54% of the reliable variance in a multitrait-multimethod assessment of 391 Italian high school students which used self-, teacher-, and parent-ratings on the Big Five Questionnaire — Children. In Study 2, a GFP was found in the seven dimensions of Cloninger's Temperament and Character Inventory as well as the Big Five of the NEO PI-R, with the GFP<sub>pci</sub> correlating  $r = .72$  with the GFP<sub>neo</sub>. These results indicate that the GFP is practically the same in both test batteries and its existence does not depend on being extracted using the Big Five model. The GFP accounted for 22% of the total variance in these trait measures, which were assessed in 651 pairs of 14- to 30-year-old Japanese twins. In Study 3, a GFP accounted for 32% of the total variance in nine scales derived from the NEO PI-R, the Humor Styles Questionnaire, and the Trait Emotional Intelligence Questionnaire assessed in 386 pairs of 18- to 74-year-old Canadian and US twins.

The results from the Japanese and Canadian twins showed that the GFP was about 50% heritable. Moreover, they showed that the higher-order GFP was a *genetic* GFP, which accounted for about 50% of the genetic variance among the various constituent traits. Further, the genetic structure closely resembled the phenotypic, observed structure. The nongenetic variance between twins was of the nonshared variety and

thus the result of unique environmental sources (e.g., an illness or chance friendship that happens to one sibling and not to the other), rather than the result of variance shared by siblings (e.g., parental socioeconomic position and child-rearing style). Shared family effects make children growing up together similar; nonshared effects make them different.

Importantly, some of the genetic variance underlying the GFP was of the nonadditive (dominance and epistasis) variety. These results replicate those reported by Rushton et al. (2008) for the GFP and by others for numerous personality scales and cognitive abilities (e.g., Bouchard & McGue, 2003; Hur, 2007; Jensen, 1998; Johnson et al., 2008; Penke et al., 2007). Non-additive genetic variance implies recent natural selection (Fisher, 1954; Falconer, 1989; Penke et al., 2007). However, caution is necessary in accepting estimates of nonadditive genetic influence due to the very large samples typically required to fully reject alternative models. In the case of the GFP, evidence for nonadditive dominance effects also comes from studies of inbreeding depression, which results when recessive (i.e., nondominant) alleles combine to lower offspring's scores on a trait relative to parents (Jensen, 1998). For example, an Italian study found inbred families were lower in extraversion and openness to experience (Camperio Ciani et al., 2007). A Dutch study revealed the offspring of parents who came from the same region in the Netherlands (and so were more likely to be inbred) scored lower on sensation seeking than those whose parents came from different regions (Rebello & Boomsma, 2007).

The well-defined positive and negative pole of the GFP (the former being more cooperative and prosocial) suggests how and why unidirectional selection for personality might have occurred from 'primeval man and his ape-like progenitors', as Darwin (1871, p. 159) phrased it. Those at the high end of the GFP — open, conscientious, outgoing, agreeable, and emotionally stable — can be expected to enjoy better social relationships and greater reproductive success since people prefer as mates, fellow workers, and leaders those who are agreeable, cooperative and emotionally stable (Figueredo et al., 2006; Miller, 2007; Van Vugt et al., 2008). Moreover, people able to co-operate in groups are also more likely to win competitions and wars (Alexander, 1979; Darwin, 1871; Geary, 2005; Van Vugt et al., 2008).

One advantage of identifying a GFP at the apex of the hierarchy is that it can clarify the underlying personality structure and thereby integrate lower-level theories. For example, studies have indicated substantial genetic pleiotropy (that is, the same genes influence several systems) both within and across factors (Ando et al., 2004; Jang et al., 2006; Jang et al., 2002; Weiss et al., 2008). Similarly, the results on trait emotional intelligence and humor style are informative because they corroborate the view that self-report measures thereon do not assess new cogni-

tive abilities or competencies, though that is often claimed by their authors (see Petrides, Pérez-González et al., 2007; Vernon, Petrides, et al., 2008). Rather, such instruments measure permutations of established personality traits that ought to be integrated into multilevel personality hierarchies, somewhere between the highly specific traits at their base and the broad general factor at their apex.

The value of an evolutionary perspective on the GFP — that it evolved as a result of natural selection for socially desirable behavior — is that it provides a guiding theory to solving purely statistical arguments about the hierarchical structure of personality that will otherwise likely go on forever. For example, a generative theoretical foundation for the coordination of traits into a substantive dimension might weigh heavily against any response set explanation of the GFP.

The confirmation of a GFP may also shed light on the neurobiology of personality. Determining the hierarchical structure of individual differences is a necessary first step to understanding the underlying conceptual nervous system (Gray, 1987; Corr, 2008). Investigators who view a GFP as occupying the apex of the hierarchy are likely to adopt a different research strategy from those who consider the Big Two, the Big Three, or the Big Five to represent the highest level. One potentially fruitful possibility is an adaptation of Gray's (1987) Behavioral Inhibition System/Behavioral Activation System (BIS-BAS) and the fundamental process of approach-avoidance. Based on sensitivity to different kinds of reinforcement, Gray's approach attempts an integration starting at the genes, working up through brain anatomy and physiology, and culminating in learning and experiential outcomes including positive and negative emotionality and motivation. Corr (2008) has outlined many of the findings and implications. Another suggestion (by DeYoung, 2006; Musek, 2007) has been that low levels of serotonin and high levels of dopamine influence the highest levels of organization because these two neurotransmitters act broadly in the brain.

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