BRIEF COMMUNICATION

Human Optimal Functioning: The Genetics of Positive Orientation Towards Self, Life, and the Future

Gian Vittorio Caprara · Corrado Fagnani · Guido Alessandri · Patrizia Steca · Antonella Gigantesco · Luigi Luca Cavalli Sforza · Maria Antonietta Stazi

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Abstract Certain personality characteristics such as self-esteem, life satisfaction, and optimism are fundamental components of positive mental health status and well-being. There is consistent evidence that these traits tend to be substantially correlated in individuals. However, no previous studies have investigated the origin of such correlation. This research used the twin method to unravel the genetic and environmental architecture of self-esteem, life satisfaction, and optimism, along with their mutual interplay. The sample was derived from the population-based Italian Twin Register, and included 428 twin pairs, aged 23–24 years. Multivariate genetic modeling showed that genes influencing self-esteem, life satisfaction, and optimism are largely overlapping. Furthermore, results indicated that the environmental components of the traits may overlap only modestly, and suggested that a sizeable amount of variance in the traits may be explained by environmental effects specific to each of them.

Keywords Positive orientation · Self-esteem · Life satisfaction · Optimism · Twins · Heritability

Introduction

The view of positive mental health, advocated by WHO, as “a state of well-being in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community” (World Health Organization 2004), has led to focus on personal strengths and potentials no less than on the various features and sources of illness. The novelty in this field is the rejection of the traditional conceptualization of well-being and ill-being as the extremes of a continuum (Ryff et al. 2006). This calls for a strong commitment of both scholars and practitioners to the identification of factors which may contribute to positive mental health or well-being, to serve in the design of interventions, and ultimately to orient public policies in a large variety of domains such as health care, work organization, and family life.

Several constructs have been proposed as appropriate and useful indicators of individual well-being, and among these, self-esteem, life satisfaction, and optimism have been demonstrated to be the most important components (Carver and Scheier 2002; Diener et al. 2002; Harter 2006; Kahneman et al. 1999). Since these constructs are substantially correlated in individuals (Diener and Diener 1995; Schimmack and Diener 2003), it was suggested by non-genetic studies that a common high-order factor could explain the phenotypic variance shared among these characteristics (Caprara and Steca 2005, 2006). This component showed high stability across time and substantial correlation with various indicators of psychological well-being. Thus, it has been interpreted as an individual propensity to positively evaluate, or to be positively “oriented” toward various life domains including oneself, and one’s future and past experiences (Caprara and Steca 2005,
This “positive orientation”, empirically constituted by a combination of high self-esteem, life satisfaction, and optimism, may properly represent the proximal sufficient cause of a “syndrome of optimal functioning” and may act as a protective factor against mental illness, and in particular against depression, in accordance with cognitive theories that posit negative views of the self, the world, and the future as fundamental aspects characterizing depression (Clark and Beck 1999).

Yet this hypothesis only relied upon genetically non-informative data, as no empirical studies have investigated the role of the genetic and environmental factors that may account for the phenotypic correlation often observed among these three personality characteristics in individuals. This point is of special interest, as several twin studies, conducted in different populations and relying on various designs and empirical construct definitions, uncovered a strong heritable component for well-being, and thus indicated that genetic effects are likely to account for a large part of observed inter-individual differences in well-being (Lykken and Tellegen 1996; Tellegen et al. 1988; Weiss et al. 2008). It has also been suggested that, in measures of subjective well-being, genetic influences may differ between genders (Roysamb et al. 2002) and may play a major role in explaining cross-time stability (Nes et al. 2006). Furthermore, subjective well-being has been reported to be genetically linked with perceived health (Roysamb et al. 2003).

To date, research interests have concentrated on the genetic and environmental determinants of self-esteem, life satisfaction, and optimism only separately for each characteristic. Studies adopting the twin method demonstrate that genetic influences on these characteristics are substantial. A major body of evidence exists for significant genetic effects on self-esteem, with heritability estimates between 30 and 50%, across gender and age (Kamakura et al. 2001; Kendler et al. 1998; Roy et al. 1995). Moreover, broad longitudinal studies indicate that the stability of self-esteem is substantially influenced by genetic factors, as well as by unshared (individual-specific) environmental influences (McGuire et al. 1999; Neiss et al. 2006; Rau vuori et al. 2007; Roy et al. 1995). The heritability of life satisfaction has been estimated at 38% by Stubbe et al. (2005), in a large sample of Dutch twins and their non-twin siblings. As regards optimism, a major environmental impact and modest heritability estimates (about 25%) have been reported in a twin/adoption study by Plomin and colleagues (Plomin et al. 1992).

Hereto are presented the results of the first population-based twin study having explored together self-esteem, life satisfaction, and optimism (hereafter also referred to as traits or dimensions), with the objective to unravel their common genetic and environmental architecture. On the basis of non-genetic data, attesting to the high degree of phenotypic correlations, it was expected that self-esteem, life satisfaction, and optimism would reveal a high degree of genetic similarities, which could account for the observed longitudinal stability of positive orientation. To examine this hypothesis, genetic correlation between the traits as estimated by two multivariate genetic models was used. These models represent alternative biological mechanisms that may underlie the observed covariance among the traits.

Methods

Participants

Subjects were derived from the population-based Italian Twin Register (ITR; Fagnani et al. 2006), which currently contains information on approximately 16,000 twins. The study sample was selected within a broad survey on attitudes and behaviors in young adulthood. In 2007, 2,930 twins aged 23–24 years, previously enrolled in the ITR, were contacted by mail and invited to participate in a survey concerning psychological well-being. In the same mail contact, the twins received the questionnaires for eliciting the measures of interest. Of the 2,930 twins contacted, 692 (24%) agreed to participate and returned the questionnaires. This response rate is in line with that of previous ITR studies (Fagnani et al. 2006). No significant differences were detected between respondents and non-respondents with respect to zygosity, education and geographical area of residence, while respondents included a significantly higher proportion of females ($P < .001$). The final sample included 428 twin pairs (251 complete, 177 unmatched), aged 23–24 years. Of the 251 complete pairs, 115 were monozygotic (MZ; 49 male–male, 66 female–female) and 136 were dizygotic (DZ; 34 male–male, 58 female–female, 44 opposite gender). No significant differences were detected between twins from complete pairs and twins from unmatched pairs with respect to response profiles or correlations for the scales.

Zygosity

The assessment of zygosity was based on a standard questionnaire aimed at evaluating the degree of physical similarity of twins during infancy; this is a well-established procedure in twin studies. DNA was also collected from the same twins for biobanking. The reliability of the questionnaire method for classifying zygosity was estimated in a sub-sample of 58 same-gender pairs using nine microsatellite markers; 54 pairs (93.1%) were correctly classified by the questionnaire.
Self-esteem

Self-esteem ($\alpha = .81$) was assessed by 7-items from the Rosenberg scale (1965), as employed by Marsh (1996), on which the participants indicated the extent to which they felt they possessed good qualities, accepted their own characteristics, and had achieved personal success or experienced failure. For each item, ratings were provided on a 4-point scale (from 1 = strongly disagree to 4 = strongly agree). An example of item for this scale is: “I feel that I have a number of good qualities”.

Life satisfaction

Subjects rated life satisfaction ($\alpha = .85$) on the 5-item Satisfaction with Life Scale (Diener et al. 1985). For each item, participants rated the extent to which they felt generally satisfied with life on a 7-point rating scale (from 1 = strongly disagree to 7 = strongly agree). An example of item for this scale is: “In most ways, my life is close to my ideal”.

Optimism

Optimism ($\alpha = .80$) was measured by using the 10-item set from Life Orientation Test (Scheier et al. 1994). In particular, the 6 scale items (4 items were “filler”) measured subjects’ expectations about their future and their general sense of optimism. Participants provided their ratings using a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). An example of item for this scale is: “In uncertain times, I usually expect the best”.

Statistical analysis

For each scale, individual mean scores over the total number of items in that scale were calculated and then used as continuous variables in all subsequent analyses. Score distribution was nearly normal, and thus no transformation was applied.

First, sample descriptives, by gender and zygosity, were computed for twins as individuals using robust estimation (as implemented in Stata, version 8.1) to take the dependence of twin data into account. Then, within-pair and within-individual correlations for self-esteem, life satisfaction, and optimism were estimated. Finally, multivariate genetic models (Martin and Eaves 1977) were fitted to the three traits, under the assumptions of the twin method (Neale and Cardon 1992). Briefly, these models are based on linear structural equations, and assume that the variation and covariation of the traits is due to additive genetic factors, shared (familial) environmental influences, and unshared (individual-specific) environmental effects.

Estimation of correlations and genetic model-fitting were performed by standard maximum-likelihood methods using the Mx software (Neale et al. 1999) and considering raw data as input. Correlations were estimated within a saturated model, and goodness of fit of genetic models was evaluated by likelihood-ratio $\chi^2$-square test and Akaike Information Criterion (AIC) relative to the saturated model. The saturated model was specified by constraining mean, variance, and within-twin covariance of the dimensions to be the same for twin and co-twin, MZ and DZ twins, and also by constraining cross-twin/cross-trait covariances (for example, between self-esteem in a twin and life-satisfaction in the co-twin, and vice versa) to be equal within each zygosity group; this implements the assumption that there is symmetry between twin and co-twin within pairs, and that twins are (as individuals) from the same base population. Gender was included as covariate in the models.

Multivariate genetic analyses were carried out by comparing two alternative models, the Independent Pathway (IP; Kendler et al. 1987) and the Common Pathway model (CP; McArdle and Goldsmith 1990), that correspond to different genetic mechanisms (Fig. 1). The IP model, where each of the latent factors has its own path to each trait, implies that the gene variants common to the traits act through distinct—possibly neurobiological—systems. The CP model is a more stringent model as it hypothesizes that covariation among the traits is due to a single latent variable, which is itself determined by genetic and environmental factors; according to this model, all the genes shared by the traits are those affecting a common susceptibility, as if these genes were in a single biochemical pathway.

Results

Sample descriptives are shown in Table 1. For self-esteem, the total number of subjects included in the analyses resulted lower than for the other two traits, due to the exclusion of (1) outliers, (2) twins with extremely incongruent response patterns (i.e., twins who apparently did not differentiate between positive and negative items from the Rosenberg scale), (3) twin pairs with perfect agreement between twin and co-twin in responses to all items of the scale, and (4) missing data.

A higher mean score for self-esteem and optimism was found in males compared to females.

Estimated within-pair and within-individual correlations for self-esteem, life satisfaction, and optimism are reported in Table 2. The correlations were estimated under a saturated model specified with a series of constraints (see above).
As denoted by the likelihood-ratio $\chi^2$ test, the fit of this model was not significantly poorer than that of the more general model without the constraints ($\chi^2(33) = 44.276, P = 0.091$). For each trait, the correlation between twin and co-twin is substantially higher in MZ than in DZ pairs, suggesting that genetic factors are likely to play a role in
the expression of the traits; for self-esteem, shared environmental effects are also evoked. Phenotypic (within-individual) correlations between the dimensions are considerable; this may well be consistent with the existence of genetic or environmental factors common to the dimensions. Finally, stronger cross-twin/cross-trait correlations in MZ than in DZ pairs point to pleiotropic effects of genes influencing the three dimensions simultaneously, and thus provide support for a genetic basis of the within-individual association among self-esteem, life satisfaction, and optimism.

The results of model-fitting analyses (Table 3) show that the variance-covariance structure of the data is best explained under the IP model, assuming genetic and unshared environmental influences ($\chi^2(6) = 6.725, P = .347; \text{AIC} = -5.275$); these influences are partly common to self-esteem, life satisfaction, and optimism, and partly specific to each trait (Fig. 1). The alternative CP model including the same sources of influence provided a poorer fit to the data ($\chi^2(8) = 16.188, P = .040; \text{AIC} = .188$). Under this model, the heritability of the common susceptibility factor was estimated at 82%.

Estimates from the best fitting IP model are reported in Fig. 2 and Table 4. Heritability (defined as the proportion of total variance in a trait due to genetic variance) is 73% for self-esteem, 59% for life satisfaction, and 28% for optimism. Genetic factors common to the traits account for at least three-quarters of the heritability of each trait.

### Table 2 Within-pair and within-individual correlations for self-esteem, life satisfaction, and optimism

<table>
<thead>
<tr>
<th></th>
<th>MZ</th>
<th>DZ</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cross-twin/Within-trait</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-esteem</td>
<td>.72 (.60–.80)</td>
<td>.50 (.35–.62)</td>
</tr>
<tr>
<td>Life satisfaction</td>
<td>.61 (.49–.70)</td>
<td>.24 (.07–.39)</td>
</tr>
<tr>
<td>Optimism</td>
<td>.30 (.14–.44)</td>
<td>.04 (−.14–.22)</td>
</tr>
<tr>
<td><strong>Phenotypic</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-esteem with life satisfaction</td>
<td>.59 (.51–.65)</td>
<td></td>
</tr>
<tr>
<td>Self-esteem with optimism</td>
<td>.51 (.43–.58)</td>
<td></td>
</tr>
<tr>
<td>Life satisfaction with optimism</td>
<td>.52 (.45–.59)</td>
<td></td>
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<tr>
<td><strong>Cross-twin/Cross-trait</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-esteem with life satisfaction</td>
<td>.53 (.43–.61)</td>
<td>.28 (.15–.40)</td>
</tr>
<tr>
<td>Self-esteem with optimism</td>
<td>.38 (.26–.48)</td>
<td>.18 (.04–.30)</td>
</tr>
<tr>
<td>Life satisfaction with optimism</td>
<td>.36 (.25–.46)</td>
<td>.12 (−.02–.26)</td>
</tr>
</tbody>
</table>

'Cross-twin/Within-trait' are correlations between twin and co-twin for the same trait

'Phenotypic' are correlations between two traits within a twin

'Cross-twin/Cross-trait' are correlations between one trait in a twin and another trait in the co-twin

MZ monozygotic, DZ dizygotic, 95% CI, 95% confidence interval

### Table 3 Model-fitting results and likelihood-ratio $\chi^2$ tests between nested models

<table>
<thead>
<tr>
<th>Model</th>
<th>$-2\ln L$</th>
<th>$df$</th>
<th>c.t.m.</th>
<th>$\chi^2$</th>
<th>$\Delta df$</th>
<th>$P$</th>
<th>AIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Saturated without constraints</td>
<td>2924.814</td>
<td>1327</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Saturated with constraints</td>
<td>2969.090</td>
<td>1360</td>
<td>1</td>
<td>44.276</td>
<td>33</td>
<td>.091</td>
<td></td>
</tr>
<tr>
<td>3. ACE independent</td>
<td>2970.963</td>
<td>1360</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. ACE common</td>
<td>2982.169</td>
<td>1364</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. AE independent</td>
<td><strong>2975.815</strong></td>
<td>1366</td>
<td>2</td>
<td><strong>6.725</strong></td>
<td>6</td>
<td>.347</td>
<td><strong>-5.275</strong></td>
</tr>
<tr>
<td>6. AE common</td>
<td>2985.278</td>
<td>1368</td>
<td>2</td>
<td>16.188</td>
<td>8</td>
<td>.040</td>
<td>.188</td>
</tr>
</tbody>
</table>

$-2\ln L$ minus twice the negative log-likelihood, $df$ degrees of freedom, c.t.m. compared to model, $\chi^2$ ($-2\ln L$ sub-model)–($-2\ln L$ full model), $\Delta df$ ($df$ sub-model)–($df$ full model), $AIC = \chi^2 - 2\Delta df$

Best-fitting model is printed in boldface

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**Note:** In parentheses are 95% confidence intervals

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![Fig. 2](image-url)
Environmental effects that are shared by the dimensions explain an important part (40%) of the variance of optimism, but have a weaker impact on the variance of self-esteem (5%) and life satisfaction (8%). For each trait, a sizeable amount of variance (22% for self-esteem, 33% for life satisfaction, 32% for optimism) is accounted for by environmental factors that are specific to the trait (Fig. 2). Shared genetic factors are responsible for large components of phenotypic correlations. Genetic correlation (that measures the extent to which two traits are affected by the same genes) is estimated at .80 for self-esteem and life satisfaction, .83 for self-esteem and optimism, and .87 for life satisfaction and optimism (Table 4); such values suggest a remarkable overlap among the sets of genes involved in the expression of the studied dimensions.

### Discussion

Biomedical research has always paid greater attention on diseases and disorders, following the assumption that understanding defective pathways is the clue for elucidating normal and effective functioning. This approach often failed, specially when dealing with optimal functioning, where mind-body interactions add complexity, and where well-being and happiness cannot be viewed as just absence of illness. The study of individual components, cognitive and emotional, that enable individuals to fully express their potentials and to fully benefit from contingent opportunities, is no less important than the study of vulnerabilities that may jeopardize their development and successful adaptation. Thus, the study of modes of viewing self, life, and future, through which people welcome opportunities, cope with adversities, and ultimately chart the course of their life, appears fundamental.

Some studies extensively attest the numerous interconnections between specific brain systems, immune efficiency, and positive affective style with happiness (Barak 2006; Elenkov 2008; Huppert et al. 2004; Rosenkrantz et al. 2003; Sharot et al. 2007). Elucidating the genetic underpinnings of these interconnections is crucial to address the pathways conducive from genes, to brain to behavior, particularly in a time in which the discovery of the great plasticity of genes discloses extraordinary opportunities to interventions aimed to promote their most desirable expressions.

The present findings show substantial heritability for self-esteem and life satisfaction, and more moderate genetic influences on optimism, in agreement with the estimates reported by Plomin and colleagues (Plomin et al. 1992). The lower heritability estimate of optimism may be interpreted in terms of the uncertainty that the future always involves, especially in young adulthood. This uncertainty may make optimism largely prone to random fluctuations due to specific environmental experiences, such as the beginning of a profession, the achievement of a better position, or the successful completion of studies.

The results also attest, for the first time, that self-esteem, life satisfaction, and optimism share a large genetic core, as indicated by the substantial portion of variance explained by the common genetic factor affecting the three dimensions simultaneously.

This shared genetic basis might represent the heritable mechanism behind individual positive orientation. However, a poorer fit of the CP compared to the IP model suggests that the genetic architecture of positive orientation is likely to be more complex than simply being mediated by a common heritable predisposition to self-esteem, life satisfaction, and optimism.

The IP model proposed here may have a relevant impact in the field of applied genetic research. Indeed, estimates of the shared genetic core from the model could allow the construction of an individual score (Boomsma et al. 1990) that could be used in genetic association studies of positive orientation; such an approach has already been successfully adopted by Hettema and associates (Hettema et al. 2008) in a recent study on anxiety spectrum phenotypes.

Beside the genetics of positive orientation, the role of environmental factors, not only shared by the dimensions but also unique to each of them, should at the same time

<table>
<thead>
<tr>
<th>Table 4 Contribution of genetic and environmental influences to the covariance between self-esteem, life satisfaction, and optimism</th>
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</thead>
<tbody>
<tr>
<td>Components of phenotypic correlations</td>
</tr>
<tr>
<td>Additive genetic influences common to the traits</td>
</tr>
<tr>
<td>Unshared environmental influences common to the traits</td>
</tr>
<tr>
<td>Genetic and environmental correlations</td>
</tr>
<tr>
<td>Additive genetic correlation</td>
</tr>
<tr>
<td>Unshared environmental correlation</td>
</tr>
</tbody>
</table>

In parentheses are 95% confidence intervals
not be neglected. Detecting such factors could be useful to implement both broad-spectrum and trait-specific intervention programs. Even though genes may determine our average set-point for positive orientation, as well as for personality traits and many dimensions of well-being, they are probably not responsible of our position within our personal range of variation at any particular time. The influential role of unique experiences deserves particular attention in order to identify the strategies more suitable to promote individual flourishing.

The main weakness of our study relates to the limited sample size. It is noteworthy that phenotypic correlations were fully comparable to those reported in previous studies of non-twin samples (Caprara and Steca 2005, 2006; Diener and Diener 1995; Schimmack and Diener 2003), indicating that our relatively small twin sample is representative of the general population with regard to the traits under investigation. However, due to a low power, we failed to detect possible shared environmental effects for self-esteem, and we could not reliably address crucial issues such as gender differences in genetic and environmental influences on the psychological measures.

In conclusion, despite some limitations, our study may provide a substantial contribution to the understanding of the genetic and environmental basis of psychological well-being. Future studies should go further in exploring the evolutionary mechanism behind the genetic constitution of positive orientation and then the links with other biological systems which played a key role in human fitness.

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References