

Genetic and Environmental Influences on Optimism and its Relationship to Mental and Self-Rated Health: A Study of Aging Twins

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Abstract Optimism has been shown to be important in maintaining wellbeing into old age, but little is known about the sources of variation in optimism and its links to mental and somatic health. Optimism, mental, and self-rated health were measured in 3,053 twin individuals (501 MZF, 153 MZM, 274 DZF, 77 DZM, and 242 DZ opposite-sex twin pairs and 561 single twins) over 50 years using the life orientation test, the General Health Questionnaire and a single-item question for self-rated health. Additive genetic factors explained 36, 34, and 46% of the variation in optimism, mental, and self-rated health, respectively, with the remainder being due to non-shared environmental influences. Genetic influences accounted for most of the covariance between the variables (14–20% of the genetic variance) indicating that in older adults genes predisposing to high optimism also predispose to good mental health and self-rated health.

Keywords Optimism · Mental health · Somatic health · Aging · Twin design

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Introduction

A large body of work has focused on negative affective states such as anger, depression and anxiety, but very little research has been done on positive affective states such as optimism, happiness, or life satisfaction. Optimism can be defined in terms of positive generalized outcome expectancies (Scheier and Carver 1985, 1993) and is an important and stable dimension of personality correlated with, but distinguishable from, constructs such as hopelessness, depression, self-esteem and locus of control.

Previous studies have proposed that positive beliefs, such as optimism, may serve as a protective buffer against future mental and somatic health problems (Atienza et al. 2002; Giltay et al. 2004, 2006; Kubzansky et al. 2001; Maruta et al. 2002; Peterson et al. 1988; Scheier and Carver 1985, 1987, 1992; Scheier et al. 1989; Seligman 1991; Taylor 1989), enhance coping strategies (Nes and Segerstrom 2006), such as in the adjustment to stress of heart disease and its treatment (Fitzgerald et al. 1993; King et al. 1998; Mahler and Kulik 2000; Matthews et al. 2004; Rasmussen et al. 2006; Scheier et al. 1989), and are advantageous in the context of adjusting to the diagnosis and treatment of cancer (Carver et al. 1993, 2005; Johnson 1996; Trunzo and Pinto 2003). Optimism also has been found to be associated with lower levels of distress after diagnosis of Acquired Immunodeficiency Syndrome (AIDS), lower risk of mortality (Maruta 2000), lower levels of depression (Seligman et al. 1979), better psychological adjustment during pregnancy and post-partum, and may be a prenatal psychosocial predictor of higher infant birth weight (Carver and Gaines 1987; Fontaine and Jones 1997; Park and Gutches 2006; Rini et al. 1999; Taylor et al. 1992). In addition, pessimism has been related to disease progression in women with an abnormal PAP smear test

(Antoni and Goodkin 1988) in that optimistic women (measured before diagnosis) were found to have less severe subsequent atypical neoplastic growth in the cervix compared to pessimistic women. Although these findings indicate an important role of optimism on well-being, little is known about the origins of individual differences in optimism. Due to this lack of knowledge and its predictive value on health variables, optimism merits special attention.

Seligman (1991) suggests that optimism could be learned by experiencing success and failure in situations throughout life. However, a significant amount of variance in optimism may be due to genetic factors (Plomin et al. 1992; Schulman et al. 1993), as other personality traits have been found to be influenced by genes, “e.g. the Big five, Type A and D personality, Altruism etc.” (Bouchard and McGue 2003; Fulker et al. 1980; Hoekstra et al. 2007; Jang et al. 2006; Koenig et al. 2007; Kupper et al. 2007; Loehlin 1992; Plomin and Nesselrode 1990; Rebollo and Boomsma 2006a, b; Taub 1998; Yamagata et al. 2006). Unlike other personality traits, which have been thoroughly investigated with the behavioural genetic paradigm, only two studies have examined the genetic basis of optimism (Plomin et al. 1992; Schulman et al. 1993). The first study (Plomin et al. 1992) measured optimism and mental health in a relatively small sample of 500 twin pairs (mean age 60.7 years, half of them reared together and half reared apart) using the Life Orientation Test (Scheier and Carver 1985) (LOT). The LOT measures generalised outcome expectancies and, in essence, optimism and pessimism. Test–retest reliability (correlation) is estimated to be 0.76–0.79 (Scheier and Carver 1985). The study by Plomin et al. (1992) reported a correlation between optimism/pessimism measured by the LOT and several mental health measures of 0.5–0.6, and showed a heritability for optimism/pessimism of 0.25. The study also revealed that genetic factors contribute considerably to associations between optimism/pessimism and mental health. The second study (Schulman et al. 1993) administered the Attributional Style Questionnaire (ASQ), another measure of optimism, to an even smaller sample (115 MZ, 27 DZ pairs, mean age 30). An MZ correlation of 0.48 and a DZ correlation of zero were found, suggesting a substantial genetic influence on optimism, but the low power due to the small sample size did not allow for partitioning of the variance into that due to additive or dominant genetic influences.

The aim of the present study was to investigate the sources of variation in optimism, measured by the LOT, as well as sources of variance in mental and physical health in middle-aged and older twins using a large sample ($N = 3,053$). We used the General Health Questionnaire (GHQ), a self-administered screening test to detect psychiatric disorders and psychological distress (Goldberg and

Williams 1988), and self-rated health (SRH), a subjective overall evaluation of health, as measurements for mental and somatic well-being, respectively. Previous research has found that 44% of individual differences in the GHQ, and 26–44% of individual differences in SRH can be explained by genetic factors (Christensen et al. 1999; Harris et al. 1992; Leinonen et al. 2005; Romeis et al. 2000; Roysamb et al. 2003; Silventoinen et al. 2007; Svedberg et al. 2001, 2005), but no study has explored the relationships between optimism, and mental and self-rated health. Thus, a further goal was to investigate the genetic and environmental contributions to the correlations between optimism, mental health and self-rated health.

Methods

Participants

The community-based sample consisted of 3,053 twin individuals ranging in age from 50 to 94 years ($M = 61 \pm 8.8$). This included 501 MZ female, 153 MZ male, 274 DZ female, 77 DZ male, 242 DZ opposite-sex twin pairs, and 561 single twins where the co-twin did not participate. The considerably fewer amount of male as compared to female twins seems to be due to male twins generally being less willing to participate in surveys (Lykken et al. 1987). The single twins were retained for the Maximum Likelihood analysis as they contribute to the estimation of means and covariate effects (thresholds). Participants were recruited from the Australian Twin Registry (ATR) (Hopper 2002), and completed a mailed questionnaire between 1993 and 1995. Details of the sampling methods are described elsewhere (Bucholz et al. 1998). Briefly, the study was conducted as a multi-wave mail-out with consent implied by return of the questionnaire. The study was approved by Queensland Institute of Medical Research Human Research Ethics Committee.

In addition to the assessment of optimism, general health (mental and self-rated), and demographic characteristics, the questionnaire covered a wide range of other health domains including personality, relationships and life events, family history, leisure activities, smoking and drinking patterns, vitamins intake, sun exposure, anxiety, and depression, and required approximately 1.5 hours to be fully completed; no reward was given for participation. Zygosity was determined by asking the twins to judge themselves as identical or non-identical based on their physical similarities, and on the degree to which they are/have been confused by others. With this method only 3.9% of the twin pairs are misclassified compared to zygosity typing using blood (Kasriel and Eaves 1976). For a small subset of the sample (6%), zygosity was subsequently

confirmed through genotyping micro-satellite markers across the genome (Cornes et al. 2005).

Measures

Revised life orientation test (LOT-R) of optimism and pessimism

The LOT-R (Scheier and Carver 1985) consists of ten items (three items assessing optimism, three items assessing pessimism, and four filler items). The two principles applied in its construction were to generate an equal number of positively worded and negatively worded items, and to word each item in such a way that it did not imply any specific basis for the expectancy. Factor analysis indicated that though there is some justification for examining the positive and negative halves of the scale separately, it is most reasonable to treat the scale as one-dimensional for most purposes (Scheier and Carver 1985). A three-point Likert scale (“yes”, “don’t know”, and “no”) was used for each item. The scale score was derived by simply adding the item scores (1–3) of the six items; a low total score indicating pessimism and a high total score optimism (Scheier and Carver 1985), with scores ranging from 6 to 18. For directional consistency with the other variables (below), we reversed the scale so that lower scores indicate more optimism. Since self-rated health is a categorical variable, the LOT score was converted to an ordinal variable with four categories. Participants who scored between 0 and 13 (19% of the sample) were assigned to category four, 14–15 (23%) to category three, 16–17 (29%) to category two, 18 (29%) to category one.

General Health Questionnaire (GHQ-12)

The General Health Questionnaire (GHQ) has been used to estimate severity and prevalence of psychological disorder. Numerous studies have demonstrated that the GHQ is a reliable and valid measure; more than 50 studies have shown that it correlates well with psychiatric diagnosis (Bowling 2005). Although the original version consists of 60 items, shorter versions which lose little in terms of validity and reliability are available (Goldberg and Williams 1988). The 12-item version of the GHQ was used, with participants being asked to rate present and recent complaints as “Better than usual” (0), “Same as usual” (1), “Less than usual” (2), or “Much less than usual” (3). The scale score was derived by adding up the item scores (0–3) with the total score ranging between 0 and 36. While scores may vary by study population, scores at 11–12 are typical, with scores above 15 indicating distress, and a score higher than 20 suggesting severe psychological distress and problems. For consistency with the other

variables, the GHQ was also analysed as an ordinal variable, with participants scoring 0–6 (25%) assigned to category one, 7–8 (31%) to category two, 9–13 (34%) to category three, 14–36 (10%) to category four.

Self-rated health (SRH)

Participants’ subjective health was assessed by a single item: “How would you describe your health at present?” Participants responded on a five-point Likert scale, ranging from “very good” (1), “good” (2), “fair” (3), to “poor” (4), and “very poor” (5). This single SRH-question has been shown to be a highly reliable and valid measure of overall health as measured by means of other indicators in all population groups (Lundberg and Manderbacka 1996). It also has been shown to be a very good predictor of mortality and the need for services (Leinonen et al. 2005) and is positively correlated with clinical assessments (Romeis et al. 2000). This strong association between SRH-question and mortality is evident throughout all studies regardless of the amount of response categories used (two- to five-point likert scales) (DeSalvo et al. 2006; Lundberg and Manderbacka 1996). Very few participants rated their health as poor (4) or very poor (5); therefore, categories 3, 4 and 5 were merged. This resulted in the assignment of 36% of the participants to category one (i.e. very good), 46% to category two (i.e. good), and 18% to category three (i.e. fair to very poor).

Statistical analysis

The classical twin design was used to partition variance in traits and covariance between traits into that due to genetic and environmental (shared within twin pairs, C, and non-shared, E) influences. This is possible as A, C, and E influences each predict different patterns of MZ and DZ twin pair correlations. As MZ twins share all their genes and DZ twins, on average, only half their segregating genes, a twin pair correlation of 1.0 would be expected for MZ pairs and 0.5 for DZ pairs if A was the only source of variance in a specific trait. Another fundamental assumption of the classical twin design is that trait-relevant environments are similar for MZ and DZ twin pairs (Kendler et al. 1993). Normally, twin correlations can be explained by a combination of these three parameters (A, C, and E) and structural equation modelling can be used to determine the combination that best explains the observed data.

Data were analysed using Maximum-Likelihood (ML) methods in Mx (Neale et al. 2002), utilising threshold modelling for ordinal data (Neale and Maes 2004). In this procedure, each twin group (MZ females, MZ males, DZ females, DZ males, and DZ opposite-sex) has two sets of

thresholds (one set for each twin) for each of the three variables included. Initially, a saturated model is fitted estimating all parameters, and then progressively more restricted models are compared to the previous model. In maximum-likelihood procedures, the minus two times log-likelihood ($-2LL$) statistics (distributed as χ^2) are compared between the nested models to test the significance of particular parameters, and hence test specific hypotheses regarding those parameters.

A trivariate Cholesky-model was fitted to assess genetic and environmental factors that mediate the phenotypic covariation between optimism and mental health and self-rated health. In the initial model we allowed for quantitative differences in the sources of variation of the three measured traits between sexes (common effects limitation-model). After estimating the relative magnitude of all parameters, sub-models were fitted to test the significance of specific parameters and to determine the most parsimonious model explaining the phenotypic variance in optimism, mental and self-rated health. Model reduction started with dropping the paths with the smallest parameter estimates.

Prior to genetic modeling, we tested each of the variables for equality of thresholds within twin pairs and across zygosity groups. We also tested for age and sex effects on the thresholds and for equality of correlations of MZ male and female pairs, and of DZ male and female pairs and opposite-sex DZ twin pairs.

Results

Preliminary analyses

No significant ($P < .05$) differences were found in the thresholds within twin pairs or across zygosity groups for optimism, mental health and self-rated health. Mental and self-rated health showed significant age effects on thresholds but no sex effects, whereas optimism showed a sex effect but no age effect. Therefore, age and sex were retained as covariates in subsequent modeling. In order to control for participation bias, we checked whether the thresholds for the variables were different in singletons compared to full pairs (Martin and Wilson 1982; Neale and Eaves 1993). For example, if the singletons had lower thresholds in the health variable (i.e. poorer health) than full pairs, this may indicate that their co-twins may have declined to participate due to poor health, as they are expected to be correlated on this variable. However, the analysis revealed that there was no significant difference in thresholds between full twin pairs and singletons, and between sexes, and, therefore, that dropout rates were independent of the three variables or sex.

Correlations

The phenotypic polychoric correlations between optimism and self-rated health (males: 0.19, females: 0.23), optimism and mental health (males: 0.26, females: 0.28), and self-rated and mental health (males: 0.24, females: 0.26) were similar in magnitude for males and females. MZ twin correlations were significantly higher than DZ twin correlations for female pairs in all variables, suggesting some genetic influence, but for males there were no significant differences between MZ and DZ twin correlations for any of the three traits even though there was a trend for genetic effects in SRH (Table 1).

Genetic modeling

As MZ twin pair correlations for optimism, mental, and self-rated health were significantly higher than DZ twin correlations in females but not in males, a common effects sex-limitation model was fitted, which allows for quantitative differences in the sources of variation of the traits between sexes. Subsequently, a general ACE model was fitted, in which proportions of A and C were constrained equally in males and females. Results showed no significant deterioration of the model fit (Table 2), indicating no sex differences in the effects of A, C, and E on the variance in the three measured traits. Furthermore, all shared-environmental (C) influences could be dropped without a significant loss of model-fit but the additive genetic (A) factor loadings could not be removed (Table 2).

As can be seen in Fig. 1, genetic factors explained 36% of the variance in optimism, 34% of the variance in mental health, and 46% of the variance in self-rated health, with non-shared environmental influences explaining the remainder. Twenty percent (i.e. $0.26^2/0.34*100$) of the genetic variance in mental health, and 14% of the genetic variance in self-rated health was explained by genetic factors shared with optimism. A further 16% of the genetic variance in self-rated health was explained by genetic factors in common with mental health. Only 2–7% of the variance due to non-shared environmental influences was explained by factors common between optimism, mental, and self-rated health.

However, while the most parsimonious explanation for the observed pattern of MZ and DZ twin pair correlations was a general AE model, both the twin pair correlations (Table 1) and path co-efficients from the full sex-limitation model (Table 3), pointed to possible differences in the sources of variance between sexes. The inability to detect these quantitative and qualitative differences between sexes might be a consequence of insufficient power due to the low number of MZ and especially DZ males as compared to the larger number of females.

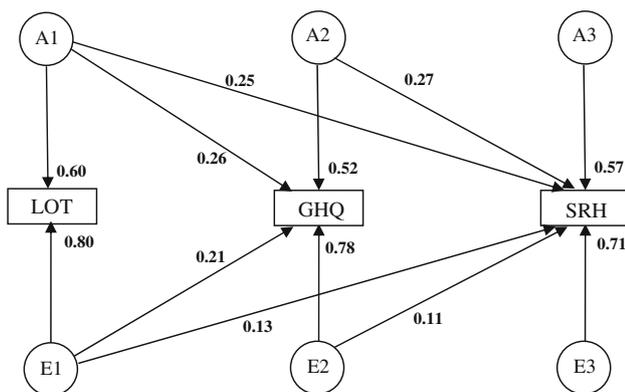
Table 1 Twin correlations (95% confidence intervals) for optimism, mental, and self-rated health corrected for age and sex for each zygosity group

Zygosity	N pairs (range)	Twin correlations (95% confidence intervals)		
		Optimism	Mental health	Self-rated health
MZ females	(416–441)	0.41 (.32, .50)	0.38 (.27, .47)	0.53 (.43, .61)
MZ males	(134–140)	0.15 (–.05, .34)	0.25 (.05, .43)	0.31 (.12, .49)
DZ females	(226–240)	0.16 (.01, .31)	0.11 (–.03, .26)	0.23 (.07, .37)
DZ males	(65–70)	0.32 (.07, .54)	0.25 (–.03, .49)	0.18 (–.12, .45)
DZ opposite-sex	(210–214)	0.10 (–.06, .25)	0.15 (–.01, .29)	0.18 (.01, .34)

MZ Monozygotic, DZ dizygotic

Table 2 Trivariate Cholesky-model fitting results for optimism, mental and self-rated health with the best fitting model in bold

Trivariate model fitting results	–2LL	df	Δ –2LL	Δ df	P-value
Common effects sex-limitation model	20,154.47	8,427			
General ACE model	20,171.72	8,445	17.252	18	0.51
Omnibus drop of all C-factors	20,171.56	8,451	–0.161	6	0.00
Omnibus drop of all A-factors	20,390.4	8,457	218.844	6	<0.01

**Fig. 1** Best fitting Cholesky-model with standardized path coefficients showing the relationship between optimism (LOT), mental (GHQ) and self-rated health (SRH). Path coefficients can be squared to get the percentage of variance accounted for. The Cholesky factors have been decomposed into additive genetic (A), common environmental (C), and unshared environmental (E) influences

Discussion

This study investigated the extent to which genetic and environmental factors influenced the variance in optimism, mental and self-rated health and their inter relations. The general model revealed a moderate genetic influence in the aetiology of optimism and both mental and self-rated health, with a heritability of 0.36, 0.34, and 0.46, respectively. All environmental influences were non-shared. In addition, the phenotypic associations between traits were largely due to common genetic factors with genes predisposing to high optimism also predisposing to good mental health and self-rated health, with additional genetic

Table 3 Model fitting results for the trivariate common effects sex-limitation model

	Females			Males		
	LOT	GHQ	SRH	LOT	GHQ	SRH
A1	0.64	0.32	0.27	0.28	0.02	0.03
A2		0.50	0.28		0.31	0.06
A3			0.61			0.44
C1	0.00	0.01	0.02	0.42	0.10	0.26
C2		0.10	0.03		0.45	0.26
C3			0.04			0.05
E1	0.77	0.16	0.13	0.86	0.31	0.14
E2		0.78	0.11		0.77	0.12
E3			0.67			0.79

Note: Separate parameter estimates are shown for females and males with the best fitting estimates in bold. Confidence intervals could not be derived due to computational limits

influences on good mental health also predisposing to good self-rated health.

The present study is the first to investigate optimism, mental and self-rated health and their associations in a genetically informative sample. The few previous genetic studies investigating optimism, and/or mental health (Plomin et al. 1992; Rijdsdijk et al. 2003; Schulman et al. 1993) found similar heritability estimates to those reported here, but the majority of them had small sample sizes. Two studies investigated heritability of optimism, while Schulman et al. (1993) does not report heritability estimates due to the extremely small sample size, Plomin et al. (1992) report a heritability of 25% for optimism in a study of 500 twin pairs.

Rijsdijk et al. (2003) (627 female MZ and 1,323 DZ) report a heritability of 44% for the GHQ which accords with our slightly lower estimate of 34%. For SRH, the finding of a heritability of 46% also accords with the more extensive literature investigating the heritability of this trait (Christensen et al. 1999; Harris et al. 1992; Leinonen et al. 2005; Roysamb et al. 2003; Silventoinen et al. 2007). Genetic factors were estimated to account for approximately 25–64% of the variance in the liability of SRH with the sample sizes ranging between $N = 434$ and 2,465.

The present analysis revealed that 14–20% of the genetic variance was due to common genes shared by the three traits measured. To date only one small study (Plomin et al. 1992) has investigated the aetiology of the covariation between optimism and mental health and found phenotypic correlations of 0.5, with genetic estimates ranging between 0.08 and 0.29 for the associations of optimism with four mental health measures. These results go in accord with our findings, suggesting genetic mediation of the phenotypic associations between optimism and mental health. It has been suggested that the association between these two variables may be due to shared covariation with neuroticism. However, Plomin et al. (1992) found that the association between optimism/pessimism and their mental health measures remained significant after controlling for neuroticism. No previous study has investigated the genetic architecture of the association between optimism and self-rated health so we cannot compare our finding of mainly genetic influences accounting for the covariation between these two variables with any previous research outcome. Finally, we found an additional genetic group factor between mental and self-rated health indicating that shared genes in mental and self-rated health independent of optimism also contribute to the associations between these two traits. While the genetic overlap between the three variables may be artifactual due to overlap in the measurement of the constructs, this is rather unlikely as there are definitional differences between the domains used. Therefore, we suggest that the phenotypic associations between optimism and health as measured here are likely due to common genes, so that genes predisposing to high optimism also predispose to good (mental and self-rated) health.

The twin correlations as well as the parameter estimates of the sex limitation model suggested possible sex differences in the genetic aetiology of all three traits. While genetic influences may account for a substantial part of the variation in and covariation between the variables in females, in males most of the variation and covariation may be largely due to shared and non-shared environmental influences. The restricted sample sizes of previous studies on optimism and mental health did not allow for investigation of sex differences. However, potential sex differences in SRH, similar to those identified here, were

reported in two earlier studies (Lichtenstein and Pedersen 1995; Svedberg et al. 2001). Also, heritability estimates (39.6%) for SRH from a large ($N = 4,638$) all male twin sample (Romeis et al. 2000) are substantially lower than those reported for females ($h^2 = 64\%$) (Leinonen et al. 2005). Despite the large sample size of the present study ($N = 3,053$ individuals), the number of complete male pairs ($N = 304$ – 317) was lower compared to female twin pairs ($N = 747$ – 788), this yielding more power to detect significant effects in females than in males. Future research should address the possibility of sex differences in the aetiology of optimism, mental health, and self-rated health with a larger sample size, as a better understanding of the complex interplay between these traits is of great importance in addressing and improving the wellbeing of those entering old age.

Results of this study cannot be generalized beyond the sample used and the measures employed. The sample included middle aged to elderly Australian twins, so results may differ for other age groups and different ethnicities. One bipolar score with a high and a low end for the optimism scale (LOT) was used, as suggested by Scheier and Carver (1985, 1987). Others (Andersson 1996) have recommended the use of bivariate scoring, as a few studies found the LOT to be bi-dimensional (Chang et al. 1994; Kubzansky et al. 2001; Marshall et al. 1992; Mroczek et al. 1993; Plomin et al. 1992). However, since the majority of previous studies (approximately 50) have used bipolar scoring, and the author of the LOT-R suggests the use of the overall score (Scheier et al. 1994), we decided to use the one-factor solution captured by the bipolar score. Our findings may have differed if optimism and pessimism had been distinguished as separate dimensions. Finally, it has been shown that a boundary problem may arise for the statistical approach used (i.e. the use of a Cholesky model), but it is not clear how much this affects the analysis of ordinal variables neither has a good solution to this potential problem been suggested (Carey 2005).

In conclusion, genetic influences appear to explain a large proportion of variance in optimism, mental health and self-rated health, as well as explaining most of the covariance between these variables. These findings indicate that the frequently reported association between optimism and health (mental and self-rated) may be due to genes predisposing to high optimism also predisposing to good mental health and self-rated health.

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