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Genetic and environmental etiology of stability and changes in self-esteem linked to personality: A Japanese twin study

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ABSTRACT

This study used a behavioral genetic approach to examine the genetic and environmental etiology of stability and changes in self-esteem in relation to personality. Multiple genetic analyses were conducted on a longitudinal dataset of self-esteem and Big Five personality scores among young adult Japanese twins over the course of a decade. There were 1221 individuals for whom data were available on both self-esteem and the Big Five personality test at Time 1 and 365 at Time 2. The mean interval between the two times was 9.95 years. Genetic effects on self-esteem were robust, and the same genes were responsible for the stability of self-esteem in individuals over time. Nearly half of the variance in self-esteem was explained by a new genetic factor arising during the decade, suggesting that genetic innovation of self-esteem occurred in early adult life. The genetic and environmental covariance structure between personality and self-esteem in individuals was constant over a decade, providing evidence that the stability of self-esteem was largely attributable to personality. However, genetics for self-esteem independent of personality still contributed to stability over time, differentiating the concept of self-esteem from personality as a trait in terms of its genetic and environmental etiological levels.

1. Introduction

Individual differences in self-esteem have been examined in several ways, such as changes over a lifetime, in relation to personality, and through underlying genetic and environmental influences. In an effort to integrate these approaches, we chose to examine them all simultaneously by using a longitudinal dataset of self-esteem and Big Five personality scores in twins over the course of a decade to explore the genetic and environmental etiology of stability and changes in self-esteem in relation to personality.

Many studies have used a longitudinal approach to examine stability and changes in self-esteem in individuals over time (e.g., Conley, 1984; Block & Robins, 1993; Robins, Hendin, & Trzesniewski, 2001). Conley (1984) compared consistency over an adult lifetime in intelligence, personality and self-opinion (including self-esteem), and noted that all three were very stable over short intervals (up to 5 years), but self-opinion was less stable in the longer term. Conley used a hierarchical longitudinal consistency model in which personality, as a higher-order construct, brought a temporal consistency to self-opinion, as a lower-order construct. A meta-analysis, however, of 168 test–retest correlation coefficients of self-esteem found that the estimated population correlation of the 10 items of the Rosenberg (1965) Self-Esteem Scale (RSES), controlling for time interval and age, was 0.5 (Trzesniewski, Donnellan, & Robins, 2003). Trzesniewski and colleagues emphasized the continuity of self-esteem over time, except after late adulthood, and noted that it was as stable as personality traits over much of the life span. Another meta-analysis of test–retest correlation coefficients for each of the Big Five dimensions from longitudinal studies estimated that population correlations, controlling for time interval and age, ranged from 0.46 to 0.55 (Roberts & DelVecchio, 2000), the same as for self-esteem.

The etiological causes underlying individual differences in self-esteem have been identified using the behavioral genetic approach (Neiss, Sedikides, & Stevenson, 2002). Behavioral genetics clarifies the genetic and environmental factors that cause individual differences in behaviors, by examining the observed resemblance between family members (Plomin, DeFries, Knopik, & Neiderhiser, 2013). The most common approach is the classical twin design, comparing similarities between

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identical (MZ) twins and fraternal (DZ) twins. Studies using this design have reported substantial genetic influences on scores for the RSES across cultures; analyses on American (Kendler, Gardner, & Prescott, 1998; Roy, Neale, & Kendler, 1995), Finnish (Raevuori et al., 2007), German (Stieger, Kandler, Tran, Pietschnig, & Voracek, 2017) and Japanese (Kamakura, Ando, & Ono, 2007) twin data suggested that approximately 30–60% of individual differences in the RSES scores among adolescents or adults were explained by genetic factors. The rest was explained by environmental factors unique to each individual and not shared between twin siblings (i.e., non-shared environmental factors). These estimates are very similar to those for personality traits. Genetic factors typically explain 30–50% of phenotypic variance in personality traits measured by self-report questionnaires, with the rest explained by non-shared environmental factors (Loehlin, 1992; Plomin et al., 2013).

The etiological causes of stability and changes in self-esteem in individuals have been examined using a longitudinal behavioral genetic approach. Analyzing Japanese adolescent and young adult twins' RSES data across two time points (mean intervals of 1.3 years), Kamakura et al. (2007) found that 49% of the phenotypic variance in self-esteem at Time 2 was explained by genetic factors that also contributed to self-esteem at Time 1, suggesting that stability of self-esteem was largely due to common genetic effects across time. The remaining 35% of the phenotypic variance at Time 2 was entirely explained by non-shared environmental factors unique to Time 2, suggesting that changes in self-esteem were because of non-shared environmental effects, not new genetic effects that arose over the course of development (i.e., genetic innovation). Raevuori et al. (2007) conducted a longitudinal behavioral genetic study among Finnish adolescent twins, with the RSES administered at 14 and 17 years old. They reported that the genetic correlation of self-esteem between the two time points did not reach unity (0.78 for boys and 0.46 for girls), suggesting the presence of genetic innovation during the teenage years.

These results are similar to those for personality traits. Previous studies have shown that the stability of personality during adulthood was largely because of genetic factors (e.g., Kandler et al., 2010; Takahashi et al., 2007), although genetic influence on personality change has also been observed (e.g., Blonigen, Carlson, Hicks, Krueger, & Iacono, 2008; McGue, Bacon, & Lykken, 1993).

Self-esteem measured through a questionnaire is correlated with personality (Bono & Judge, 2003; Erdle, Gosling, & Potter, 2009; Schmitt & Allik, 2005). Previous studies among adults have indicated that correlation coefficients between self-esteem, as measured by the RSES, and the Big Five personality dimensions, as measured by the NEO Five Factor Inventory or NEO-PI-R (Costa & McCrae, 1992), range from approximately − 0.60 to just over − 0.70 for neuroticism, from 0.30 to approximately 0.40 for extraversion, around 0.10 to 0.20 for openness to experiences, around 0.20 for agreeableness, and from approximately 0.20 to 0.40 for conscientiousness in the US (Kwan, Bond, & Singelis, 1997; Robins et al., 2001; Judge, Erez, & Bono, 2002), Hong Kong (Kwan et al., 1997), and Estonia (Pullmann & Allik, 2000).

To our knowledge, however, only a few behavioral genetic studies, all using an American twin sample, have analyzed RSES and personality data simultaneously to clarify their associations at etiological genetic and environmental levels. Neiss et al. (2005) reported that overlaps among self-esteem, executive self, and negative affectivity in adults was mainly because of common genetic factors. Roberts and Kendler (1999) also identified common genetic factors in neuroticism, self-esteem, and major depression in females. Both studies also reported genetic effects unique to self-esteem.

Previous studies therefore suggest that adult self-esteem and personality are both stable over time, as a result of common genetic factors. Self-esteem and personality are significantly correlated, again because of a common genetic factor. These previous studies have two main limitations, however. First, the longitudinal behavioral genetic studies on self-esteem had a relatively short interval, so the etiology of stability and change over a longer period remains unclear. Second, behavioral genetic studies on the association between personality and self-esteem were all cross-sectional, so longitudinal etiological relationships between the two constructs remain unclear.

The purpose of this study was therefore two-fold. First, we wanted to explore the etiology of stability and changes in self-esteem over a decade in adulthood. The longer interval might allow a genetic contribution to changes in self-esteem (i.e., genetic innovation) to appear, and therefore provide more convincing evidence of the influence of genetic factors on self-esteem, or enable us to confirm that changes in self-esteem are solely because of environmental effects. Second, with measures of Big Five personality dimensions, we examined longitudinal associations between personality and self-esteem. This enabled us to examine the extent to which individual differences in self-esteem are rooted in stable genetic and environmental influences on personality. Decay in the predictive power of personality traits after a decade would imply that the genetic and environmental basis of self-esteem changes from personality traits to other psychological traits, or to self-esteem itself (i.e., emergence or increment of genetic and environmental influence unique to self-esteem). Alternatively, personality traits might be the genetic and environmental basis of self-esteem, regardless of age or time.

We used longitudinal and multivariate genetic analysis. This allowed us to decompose the phenotypic covariance among variables into its genetic and environmental components. We decomposed the genetic and environmental components of self-esteem at the first time point into (a) those also linked to personality and (b) those specific to self-esteem. At the second time point, we decomposed the genetic and environmental components of self-esteem into (a′) those also linked to personality, (b′) those independent of personality but linked to self-esteem at the first time point, and (c) those specific to self-esteem at the second time point. The presence of (c) indicates genetic or environmental origin of the change in self-esteem. The presence of (b) or (b′) suggests a genetic or environmental basis of self-esteem that is independent of personality. Comparison of (a) and (a′) would show to what extent individual differences in self-esteem are rooted in stable genetic and environmental influences on personality.

2. Methods

2.1. Participants

The Keio Twin Study (KTS) recruited 14–30-year-old Japanese volunteer twin participants through population-based registries in some parts of the Tokyo area in 1998–2011 (for a detailed description of the sample and surveys, see Shikishima, Ando, Ono, Toda, & Yoshimura, 2006 and Ando, Fujisawa, Shikishima, Hiraishi, Yamagata, Neiderhiser, & Ando, 2013). The researchers issued comprehensive postal surveys, including the self-esteem measure, in 1999–2005 (Time 1) and in 2012 (Time 2). In total, 1317 individuals responded to the questionnaire at Time 1 and 1186 at Time 2. A total of 382 individuals responded to both. The number of effective twin pairs according to zygosity and sex is presented in Table 1. The age of the survey respondents ranged from 15 to 33 years (M = 21.20 and SD = 4.43) for Time 1 and from 20 to 47 years (M = 26.62 and SD = 4.96) for Time 2. The interval between Times 1 and 2 ranged from 6 to 14 years (M = 9.95 and SD = 1.94).

Among the respondents, 1221 participants with Time 1 self-esteem scores and 365 individuals with Time 2 self-esteem scores also responded to the Big Five personality test included in the other postal survey conducted by the KTS in 1998–2004, administered at approximately the same time as the Time 1 self-esteem questionnaire. The respective number of twin pairs across variables is presented in Table 1 according to zygosity and sex. In total, 357 individuals (91 female MZ, 29 male MZ, 20 female DZ, 1 male DZ, and 10 opposite-sex DZ complete twin pairs) responded to all the surveys. Their age range was 15 to 32 (M = 21.23 and SD = 4.46) at Time 1 and 24 to 40 (M = 31.32 and

Table 1
Sample size across variables.

		Personality	SE1	SE2
MZ	Personality	282(17)/130(11)		
	Self-esteem Time 1	277(18)/125(15)	302(16)/136(12)	
	Self-esteem Time 2	92(28)/30(15)	98(28)/31(15)	286(72)/82(33)
DZ same-sex	Personality	78(6)/40(1)		
	Self-esteem Time 1	78(6)/40(0)	83(4)/42(1)	
	Self-esteem Time 2	20(5)/1(5)	21(6)/1(5)	67(26)/14(14)
DZ opposite-sex & unknown zygosity	Personality	67(9)		
	Self-esteem Time 1	66(10)	74(10)	
	Self-esteem Time 2	10(6)	11(4)	55(33)

Note: Numbers of complete female pairs are presented on the left and male pairs on the right. Numbers of incomplete pairs are in brackets.

SD = 4.32) at Time 2. There was substantial attrition of cases, but Little's (1988) test indicated that the data were missing completely at random ($\chi^2(219) = 219.13$, $p = 0.48$). Signed informed consent was obtained from all participants at the time of each survey.

The zygosity of each same-sex twin pair was initially diagnosed by a three-item questionnaire based on physical resemblance (Ooki, Yamada, Asaka, & Hayakawa, 1990). Gene polymorphisms were examined in nearly half the pairs. It was confirmed that 93.3% of these DNA-based diagnoses were in agreement with the initial questionnaire-based diagnoses. The opposite-sex DZ pairs were excluded from twin intra-class correlation analyses and multivariate genetic analyses.

2.2. Measures

Self-reported self-esteem was assessed using the Japanese version of the 10-item Rosenberg Self-Esteem Scale (RSES; Rosenberg, 1965; Yamamoto, Matsui, & Yamanari, 1982). The items are coded on a five-point Likert-type scale ranging from 5 (strongly agree) to 1 (strongly disagree). Cronbach's α for the scale was 0.85 for Time 1 and 0.86 for Time 2.

Personality was measured using the Five-Factor Model, which assesses broad aspects of personality. We used the Japanese version of the 240-item Costa and McCrae (1992) NEO-PI-R (Yamagata et al., 2006). The items are coded on a five-point Likert-type scale and identify five personality factors: neuroticism, extraversion, openness to experiences, agreeableness, and conscientiousness.

2.3. Statistical analyses

2.3.1. Phenotypic analyses

Means, standard deviations, and ranges were calculated for the two self-esteem time points and the five personality dimensions, and age and sex effects examined. Phenotypic correlations were analyzed by computing Pearson correlation coefficients between the two time points for self-esteem and the five personality dimensions to characterize phenotypic associations. SPSS 22.0 was used throughout.

2.3.2. Twin intra-class correlation analyses

For each of the two time points of self-esteem and the five personality dimensions, similarities were compared between MZ and same sex DZ twin pairs. MZ twin pairs share the same genes and common family environment, whereas DZ twin pairs share an average of half their segregating genes and a common family environment. We can therefore assume that the genetic similarity is twice as high for MZ twin pairs, but MZ and DZ have the same shared environmental similarity. Intra-class correlations that are higher for MZ than DZ twin pairs indicate the presence of genetic effects. Lack of differences in intra-class correlations between the two types of twin pairs suggest the influence of shared environmental effects without genetic effects.

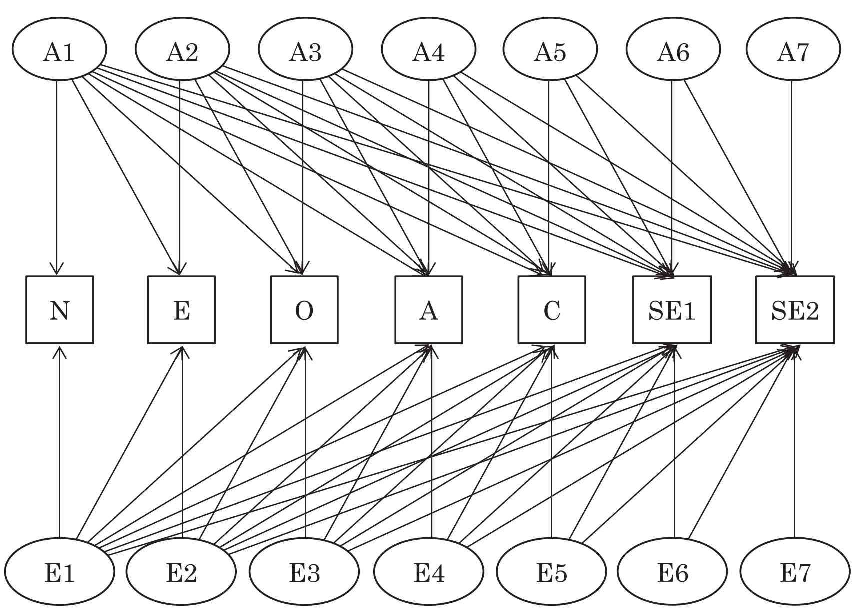

Fig. 1. Seven-variable Cholesky decomposition model postulating latent additive genetic (A) and non-shared environmental (E) factors (AE Cholesky model) for each of the five personality dimensions and time measurements of self-esteem. N: neuroticism, E: extraversion, O: openness to experiences, A: agreeableness, C: conscientiousness, SE1: self-esteem at the first time point, SE2: self-esteem at the second time point.

2.3.3. Multivariate genetic analyses

Multivariate genetic analyses with a Cholesky decomposition were performed on raw data using the full information maximum likelihood estimation. This allowed us to correct statistical biases based on the inclusion of individual cases missing some measures or data from the other twin (Neale & Maes, 2002).

The Cholesky decomposition decomposes the twins' phenotypic variance and covariance into components attributable to additive genetic (A), dominance genetic (D), shared environmental (C), and non-shared environmental (E) influences. All the measurement error components are also included in the non-shared environmental effect. Fig. 1 shows the model based on the AE Cholesky decomposition, postulating additive genetic and non-shared environmental factors for all variables. The overall magnitude of genetic and environmental mediations between the five personality dimensions and self-esteem at Time 1 (from A1–5 and E1–5 to SE1), and between the five personality dimensions and self-esteem at Time 2 (from A1–5 and E1–5 to SE2), as well as genetic and environmental effects on self-esteem independent of personality dimensions (from A6 and E6 to SE1 and 2), and independent of both personality dimensions and self-esteem at Time 1 (from A7 and E7 to SE2) were estimated using a seven-variable Cholesky decomposition. In a series of model-fitting analyses, we fitted first the saturated model and then the full models (ADE and ACE models) to the data, followed by sub-models (AE, CE, and E models) and nested and more constrained models.

The indices of model fit were compared to identify the model that best accounted for all seven variables. To evaluate the comparative fit of competing models, we relied on fit indices not influenced by sample size, which differed across variables in the multivariate genetic analysis, and reported differences in values in Akaike's information criterion (AIC) and the Bayesian information criterion (BIC) from the saturated model as overall fit. Model difference tests used chi-squared significance tests on differences in the log-likelihood (−2LL) between the two nested models being compared. The contribution of each parameter to the best-fitting model was estimated as a standardized path coefficient.

We also described the extent to which the genetic effects on one variable overlapped those on another, obtaining a genetic correlation coefficient by converting path coefficients. The shared environmental correlation and non-shared environmental correlation were also obtained using the best-fitting model. The Mx software package was used for genetic analyses (Neale, 2004).

3. Results

3.1. Phenotypic analyses

Table 2 shows the descriptive statistics for self-esteem at the two time points and the five personality dimensions. No significant mean differences were observed for any measures between first-born and second-born twins and between zygosities except for extraversion (DZ > MZ, $p < 0.05$). Weak but significant age and sex effects were observed in several variables, so scores were controlled for age and sex effects in the subsequent analyses.

Table 2
Descriptive statistics.

	N	Min	Max	Mean	SD	Age effect	Sex effect
Self-esteem Time 1	1317	10	50	32.57	7.03	0.12***	−0.11***
Self-esteem Time 2	1186	10	50	32.16	7.40	0.12***	0.05
Neuroticism	1238	37	177	106.04	22.05	−0.11***	−0.12***
Extraversion	1238	34	173	100.03	19.95	−0.05	−0.05
Openness to experiences	1238	65	158	109.82	15.03	0.06*	−0.05
Agreeableness	1238	41	159	110.11	15.12	0.05	−0.09**
Conscientiousness	1238	22	173	97.66	19.22	0.12***	0.02

Note: Age effect is presented as Pearson correlation coefficients with age. Sex effect is presented as Pearson correlation coefficients with sex when female scores are 0 and male scores are 1. Data are included for any twins where at least one self-esteem measure was available for at least one of the pair.
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

The phenotypic correlation between self-esteem at the two time points was 0.59 (Table 3). The largest phenotypic correlation between personality and self-esteem was between neuroticism and self-esteem at Time 1 ($r = -0.60$) followed by neuroticism and self-esteem at Time 2 ($r = -0.45$). The correlation between extraversion and self-esteem was 0.41 at Time 1 and 0.43 at Time 2. Between conscientiousness and self-esteem, it was 0.44 at Time 1 and 0.30 for Time 2.

3.2. Twin intra-class correlation analyses

Intra-class correlations for MZ twin pairs were higher for all variables ($r = 0.38$–0.54) (Table 4). Those for DZ twin pairs were half or less than those for MZ pairs ($r = 0.04$–0.28), suggesting that resemblance between twin pairs is attributable to genetics.

3.3. Multivariate genetic analyses

The results of the model-fitting analysis are shown in Table 5. The AE Cholesky model fit better than ADE, ACE, CE, and E models. Imposing equality constraints between the five paths from the additive genetic factors of the five personality dimensions (A1–5) to self-esteem at Times 1 and 2 did not significantly worsen the model fit. This was also the case for non-shared environmental factors (E1–5). The equality constraints for both additive genetic and non-shared environmental factors therefore improved the model fit, suggesting that the effects of additive genetic and non-shared environmental factors of personality on self-esteem are invariant across Times 1 and 2.

The results also revealed that the additive genetic residual controlling for personality dimensions (A6) made an equal contribution to self-esteem scores at Times 1 and 2. The non-shared environmental residual controlling for personality dimensions (E6) did not mediate self-esteem scores at Times 1 and 2. This indicates that the stability of self-esteem that is independent of personality dimensions was because of genetic factors. Finally, dropping the additive genetic factor specific to self-esteem at Time 2 (A7) significantly worsened the model fit, suggesting that a new additive genetic factor for self-esteem could arise at Time 2.

The genetic covariance between personality dimensions and self-esteem was the same across the two time points. For example, the genetics of neuroticism explained 20–23% of the phenotypic variance in self-esteem (Table 6; $-0.48^2 = 23.04\%$ for self-esteem at Time 1 and $-0.45^2 = 20.25\%$ at Time 2). The non-shared environmental covariance between neuroticism and self-esteem was also large, explaining about 10% of variance across the two time points. Overall, the genetics of personality explained approximately 30% of the phenotypic variance in self-esteem over time, and non-shared environmental factors of personality explained nearly 15%.

After controlling for personality, however, 10–12% of the phenotypic variance in self-esteem was accounted for by a common genetic factor contributing to both Times 1 and 2 (Table 6; $0.34^2 = 11.56\%$ for self-esteem at Time1 and $0.32^2 = 10.24\%$ at Time 2). The new genetic factor at Time 2 explained another 13% of the variance in self-esteem at Time 2. Non-shared environmental factors exhibited mutual independence between self-esteem at Times 1 and 2, causing 42% and 36% of variance. These were the main etiological source of self-esteem.

Compared to the phenotypic correlation of 0.59, the genetic correlation was 0.86 and the non-shared environmental correlation only 0.27 between self-esteem at Times 1 and 2 (Table 3). The largest genetic correlations between personality and self-esteem were for neuroticism, −0.74 at Time 1, and −0.63 at Time 2, and the second largest for conscientiousness, 0.63 and 0.54. Non-shared environmental

Table 3
Phenotypic, genetic, and non-shared environmental correlations.

Correlations		Neuroticism	Extraversion	Openness to experiences	Agreeableness	Conscientiousness	Self-esteem Time 1
Phenotypic	Self-esteem Time 1	**− 0.60**	**0.41**	**0.26**	**− 0.08**	**0.44**	–
		(− 0.64, − 0.54)	(0.34, 0.47)	(0.18, 0.33)	(− 0.16, − 0.00)	(0.37, 0.50)	
	Self-esteem Time 2	**− 0.45**	**0.43**	**0.18**	0.05	**0.30**	**0.59**
		(− 0.55, − 0.33)	(0.31, 0.53)	(0.04, 0.30)	(− 0.09, 0.18)	(0.17, 0.42)	(0.49, 0.67)
Additive genetic	Self-esteem Time 1	**− 0.74**	**0.48**	**0.33**	− 0.06	**0.63**	–
		(− 0.83, − 0.65)	(0.36, 0.58)	(0.31, 0.45)	(− 0.22, 0.11)	(0.52, 0.73)	
	Self-esteem Time 2	**− 0.63**	**0.41**	**0.28**	− 0.05	**0.54**	**0.86**
		(− 0.73, − 0.53)	(0.39, 0.52)	(0.16, 0.38)	(− 0.18, 0.09)	(0.44, 0.64)	(0.85, 0.93)
Non-shared environmental	Self-esteem Time 1	**− 0.43**	**0.36**	**0.16**	− 0.03	**0.22**	–
		(− 0.49, − 0.36)	(0.29, 0.43)	(0.08, 0.24)	(− 0.08, 0.05)	(0.13, 0.29)	
	Self-esteem Time 2	**− 0.43**	**0.37**	**0.16**	− 0.04	**0.22**	**0.27**
		(− 0.43, − 0.36)	(0.34, 0.44)	(0.09, 0.24)	(− 0.08, 0.05)	(0.14, 0.28)	(0.21, 0.34)

Note: Phenotypic correlations were computed using datasets of randomly selected one twin for each complete pair and all twins for each incomplete pair. Numbers of individuals for phenotypic correlations were 635 between Self-esteem Time 1 and Personality, 212 between Self-esteem Time 2 and Personality, and 220 between Self-esteem Times 1 and 2. Numbers of complete MZ and DZ twin pairs for additive genetic and non-shared environmental correlations were 402 and 118 between Self-esteem Time 1 and Personality, 122 and 21 between Self-esteem Time 2 and Personality, and 129 and 22 between Self-esteem Times 1 and 2, respectively. Additive genetic and non-shared environmental correlations were computed from the best-fitting model. 95% confidential intervals are in brackets. Coefficients whose 95% confidence interval did not include zero are shown in boldface.

Table 4
Twin intra-class correlations.

	MZ		DZsame-sex	
	r	n of pairs	*r*	n of pairs
Self-esteem Time 1	0.39	438	0.19	125
Self-esteem Time 2	0.54	368	0.28	81
Neuroticism	0.44	412	0.20	118
Extraversion	0.49	412	0.17	118
Openness to experiences	0.51	412	0.28	118
Agreeableness	0.38	412	0.04	118
Conscientiousness	0.52	412	0.14	118

correlations were smaller; the coefficients with neuroticism were − 0.43 for both Times 1 and 2, and with extraversion were 0.36 and 0.37.

4. Discussion

This study confirmed the role genes play in self-esteem in two important ways; however, we should cautiously interpret the results given that the number of twin pairs in the datasets (self-esteem at Times 1 and 2 and Big Five data) was quite small. First, unlike previous studies (e.g., Kamakura et al., 2007; Raevuori et al., 2007; Trzesniewski et al., 2003), we used a dataset collected over a decade, and showed that genes were responsible for the stability of self-esteem within individuals over time,

Table 5
Model-fitting indices for multivariate analyses.

Model #		Overall fit				Compared to model #	Model difference test		
		-2LL	*df*	⊿AIC	⊿BIC		⊿χ2	⊿*df*	*p*
1	Saturated	59766.12	7438						
2	ADE Cholesky	59950.24	7585	− 109.88	− 414.55	1	184.12	147	0.020
3	ACE Cholesky	59956.95	7585	− 103.16	− 411.19	1	190.84	147	0.009
4	AE Cholesky	59959.93	7613	− 156.18	− 506.20	1	193.82	175	0.157
5	CE Cholesky	60025.75	7613	− 90.37	− 473.29	1	259.63	175	< 0.001
6	E Cholesky	60654.70	7641	482.58	− 255.31	1	888.58	203	< 0.001
4a	Model 4 with equality constraints between A1-A5 to SE1 and A1-A5 to SE2 i.e., AE model with $a_{61} = a_{71}$, $a_{62} = a_{72}$, $a_{63} = a_{73}$, $a_{64} = a_{74}$, and $a_{65} = a_{75}$	59967.99	7618	− 158.13	− 519.40	4	8.06	5	0.153
4b	Model 4 with equality constraints between E1-E5 to SE1 and E1-E5 to SE2 i.e., AE model with $e_{61} = e_{71}$, $e_{62} = e_{72}$, $e_{63} = e_{73}$, $e_{64} = e_{74}$, and $e_{65} = e_{75}$	59968.05	7618	− 158.07	− 519.37	4	8.12	5	0.150
4c	Model 4 with equality constraints between A1-A5 to SE1 and A1-A5 to SE2 and between E1-E5 to SE1 and E1-E5 to SE2 i.e., AE model with $a_{61} = a_{71}$, $a_{62} = a_{72}$, $a_{63} = a_{73}$, $a_{64} = a_{74}$, $a_{65} = a_{75}$, $e_{61} = e_{71}$, $e_{62} = e_{72}$, $e_{63} = e_{73}$, $e_{64} = e_{74}$, and $e_{65} = e_{75}$	59975.80	7623	− 160.31	− 532.73	4	15.87	10	0.103
4c_1	Model 4c with an equality constraint between A6 to SE1 and A6 to SE2 i.e., AE model with $a_{61} = a_{71}$, $a_{62} = a_{72}$, $a_{63} = a_{73}$, $a_{64} = a_{74}$, $a_{65} = a_{75}$, $e_{61} = e_{71}$, $e_{62} = e_{72}$, $e_{63} = e_{73}$, $e_{64} = e_{74}$, $e_{65} = e_{75}$, and $a_{66} = a_{76}$	59977.02	7624	− 161.09	− 535.56	4c	1.22	1	0.269
4c_2	Model 4c with an equality constraint between E6 to SE1 and E6 to SE2 i.e., AE model with $a_{61} = a_{71}$, $a_{62} = a_{72}$, $a_{63} = a_{73}$, $a_{64} = a_{74}$, $a_{65} = a_{75}$, $e_{61} = e_{71}$, $e_{62} = e_{72}$, $e_{63} = e_{73}$, $e_{64} = e_{74}$, $e_{65} = e_{75}$, and $e_{66} = e_{76}$	60133.69	7624	− 4.43	− 457.23	4c	157.89	1	< 0.001
4c_1a	**Model 4c_1with no contribution from E6 to SE2 i.e., AE model with $a_{61} = a_{71}$, $a_{62} = a_{72}$, $a_{63} = a_{73}$, $a_{64} = a_{74}$, $a_{65} = a_{75}$, $e_{61} = e_{71}$, $e_{62} = e_{72}$, $e_{63} = e_{73}$, $e_{64} = e_{74}$, $e_{65} = e_{75}$, $a_{66} = a_{76}$, and $e_{76} = 0$**	**59979.05**	**7625**	**− 161.06**	**− 537.99**	**4c_1**	**2.03**	**1**	**0.154**
4c_1a_1	Model 4c_1_a with no specific A factor for SE2 i.e., AE model with $a_{61} = a_{71}$, $a_{62} = a_{72}$, $a_{63} = a_{73}$, $a_{64} = a_{74}$, $a_{65} = a_{75}$, $e_{61} = e_{71}$, $e_{62} = e_{72}$, $e_{63} = e_{73}$, $e_{64} = e_{74}$, $e_{65} = e_{75}$, $a_{66} = a_{76}$, $e_{76} = 0$, and drop A7	59991.56	7626	− 150.56	− 535.19	4c_1a	12.51	1	< 0.001

Note: -2LL: -2 log-likelihood of the model, *df*: degree of freedom, ⊿AIC: difference in Akaike's Information Criterion from the saturated model, ⊿BIC: difference in Bayesian Information Criterion from the saturated model, $\Delta\chi^2$: difference in -2LL between nested models, ⊿*df*: difference in degree of freedom between nested models, *p*: *p* value associated with χ^2 Additive genetic and nonshared environmental path coefficients are represented as a_{ij} and e_{ij}, respectively, where $_i$ indicates the row number and $_j$ indicates the column number of the matrix shown in Table 6. The best-fitting model is shown in boldface.

Table 6
Parameter estimates of best-fitting model (standardized solutions).

	A1	A2	A3	A4	A5	A6	A7	E1	E2	E3	E4	E5	E6	E7
1. Neuroticism	**0.66**							**0.75**						
2. Extraversion	**− 0.21**	**0.66**						**− 0.22**	**0.69**					
3. Openness to experiences	− 0.04	**0.17**	**0.69**					− 0.05	**0.25**	**0.65**				
4. Agreeableness	− 0.07	**0.02**	− 0.01	**0.60**				**− 0.14**	0.07	**0.12**	**0.77**			
5. Conscientiousness	**− 0.42**	**0.13**	0.00	− 0.02	**0.57**			**− 0.20**	**0.05**	**0.10**	**0.01**	**0.66**		
6. Self-esteem Time 1	**− 0.48**	**0.18**	**0.15**	**− 0.10**	**0.12**	**0.34**		**− 0.32**	**0.18**	0.03	**− 0.11**	**0.06**	**0.65**	
7. Self-esteem Time 2	**− 0.45**	**0.17**	**0.14**	**− 0.09**	**0.11**	**0.32**	**0.37**	**− 0.30**	**0.17**	**0.03**	**− 0.10**	**0.05**	0.00	**0.60**

Note: A represents an additive genetic factor and E represents a non-shared environmental factor. Contributions whose 95% confidence interval did not include zero are shown in boldface.

as has previously been shown for personality, psychopathology, and intelligence (Plomin, DeFries, Knopik, & Neiderhiser, 2016).

Second, our findings suggested that nearly half of the variance in self-esteem was explained by new factors not present a decade before. This had not been found in previous studies on self-esteem that had used data from shorter periods in adulthood. Of the variance, 30% was because of a new genetic factor for self-esteem, indicating that genetic innovation in self-esteem occurred in early adult life. This finding is consistent with previous literature on personality that also found genetic innovation in late adolescence to early adulthood (e.g., Blonigen et al., 2008; McGue et al., 1993). The age of the sample in this study ranged from the teenage years to the forties, and the factor that caused a new self-esteem genetic factor to emerge during these time periods is unknown; however, our study provides additional evidence that genetics can play a role in both stability and changes in self-esteem.

More than 70% of change was accounted for by non-shared environmental effects. These include measurement error variance, so we need to be cautious in interpreting the estimates for non-shared environmental effects. The large contribution of non-shared environmental factors, independent of time, allows us to suggest that self-esteem measured by the RSES successfully reflects overall state and individual experiences.

The phenotypic correlations between the Big Five dimensions and self-esteem were mostly in line with those reported in previous studies (Schmitt & Allik, 2005). The genetic and environmental covariance structure between personality and self-esteem was invariant over a decade within the individuals. Our study provides evidence that the stability of self-esteem is largely attributable to personality, because personality and self-esteem were continuously mediated by common genetic and non-shared environmental factors. It could be argued that the high and long-lasting genetic correlations between personality and self-esteem mean that they are the same construct. Genetics independent of personality, however, also contributed to the stability of self-esteem over time. Our findings differentiate the concept of self-esteem from personality as a stable trait in terms of its genetic and environmental etiological levels.

Finally, our findings are important for the controversy surrounding the positivity of Japanese self-esteem in the field of cultural psychology. Since Japanese self-esteem was shown to have a genetic basis similar to Westerners, the present study provides additional support for the functional equivalence of self-esteem across cultures (Sedikides, Gaertner, & Toguchi, 2003; Yamaguchi et al., 2007). Therefore, cultural psychologists should consider adopting a behavioral genetic approach (Shikishima et al., 2013).

Conflict of interest statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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