Genetic and Environmental Contributions to Personality Trait Stability and Change Across Adolescence: Results From a Japanese Twin Sample

Tetsuya Kawamoto[1,2] and Toshihiko Endo[2]
[1]Research Fellow of the Japan Society for the Promotion of Science
[2]The University of Tokyo, Bunkyo-ku, Tokyo, Japan

We examined developmental trends and sources of stability and change in adolescent personality by using twin data collected from 1981 to 2010 (273 monozygotic (MZ) and 48 dizygotic (DZ) twin pairs) from a secondary school affiliated with the University of Tokyo. Phenotypic analyses showed high rank-order stability and substantial mean-level increases in neuroticism and declines in extraversion over the adolescent years. Longitudinal bivariate genetic analyses revealed that the best-fitting model for adolescent personality includes additive genetic and non-shared environmental influences. Heritability estimates ranged approximately from 0.30 to 0.60. Additionally, three-year stability in adolescent personality was influenced mainly by genetic factors, and there were both genetic and environmental innovations in mid-adolescence. Our findings suggest that both genetic and environmental effects have significant roles in the etiology of personality development across adolescence.

∎ **Keywords:** personality change, adolescence, behavioral genetics, Japanese, twin

Many studies examining stability and change in personality have been conducted over the past 20 years. Two types of stability and change at the population level, mean-level change, and rank-order stability have been examined in those studies (for meta-analytic reviews, see Roberts & DelVecchio, 2000; Roberts et al., 2006).

To date, both longitudinal and cross-sectional studies have reported mean-level personality changes in the Big Five, which measures human personality in five domains—Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness to Experiences—and is widely used (John et al., 2008) across the life span. Taking particular note of mean-level personality change across adolescence, the findings of previous studies were inconsistent. The meta-analytic results by Roberts et al. (2006) indicated significant increases in social dominance, one of the facets of Extraversion, and emotional stability, the opposite pole to Neuroticism, across adolescence. Two studies also showed increases in Extraversion (Canals et al., 2005; Pullmann et al., 2006); in contrast, other studies have failed to observe a significant change in Extraversion (Allik et al., 2004; De Fruyt et al., 2006; Klimstra et al., 2009; McCrae et al., 2002), or conversely, have found its decline (Branje et al., 2007; Lamb et al., 2002; Soto et al., 2011; Van den Akker et al., 2014). In respect of Neuroticism, De Fruyt et al. (2006), Klimstra

et al. (2009), and the meta-analysis results by Roberts et al. (2006) indicated declines in Neuroticism (i.e., increases in emotional stability). Alternatively, some previous studies have failed to observe a significant change in Neuroticism (Allik et al., 2004; Branje et al., 2007; Lamb et al., 2002; Pullman et al., 2006), or found an increase, especially in female adolescents (Canals et al., 2005; McCrae et al., 2002; Soto et al., 2011; Van den Akker et al., 2014).

The literature shows that there is change and stability in Extraversion and Neuroticism; however, these findings are inconsistent. Moreover, the results were all drawn from Western adolescent samples, which suggest some degree of bias. To offer new insight into research regarding personality development, we need data from non-Western countries.

Further, the preceding studies explain only the description of the phenomenon and do not provide information about the causal relationship, namely, which factors contribute to the stability or change of personality during

545

specific periods of the lifespan. Behavioral genetic studies on longitudinal data offer ways to reveal the genetic and environmental factors contributing to stability and change in personality (Johnson, 2008). It is considered a firm fact that heritability estimates for broad personality traits, like the Big Five, fall about approximately 0.50. Although the remaining variance is derived from non-shared environmental influences, which make twins within the same family more different from each other, shared environmental influences, which make twins within the same family more similar to each other, seem to play only a limited role (for reviews, see Johnson et al., 2008; Turkheimer et al., 2014).

Several longitudinal behavioral genetic studies on personality development have recently been conducted. These studies focused on three issues: change and stability in heritability and environmentality during the measurement interval, change and stability in genetic and environmental influences on personality over time, and the extent of genetic and environmental influences on change and stability in personality (Bleidorn et al., 2014). As for the first issue, although some studies focusing on young adulthood showed heritability and environmentality are stable during the interval (Blonigen et al., 2008; Bratko & Butkovic, 2007; Hopwood et al., 2011), other empirical studies (Kandler et al., 2010; 2013; McGue et al., 1993) and a meta-analytic review (Kandler, 2012) indicated that heritability of specific personality traits decreases during the whole of adulthood. Based on the latter, Bleidorn et al. (2014) argued that genetic factors seem to be most important in early adulthood and tend to decrease during middle and older adulthood.

With respect to the second issue, previous studies have examined these factors by two indexes: genetic correlation (r_g) and environmental correlation (r_e). Genetic or environmental correlation, representing the rank-order stability of genetic or environmental factors over two measurement points, means the degree to which individual differences in genetic or environmental factors remain stable over time. Therefore, when a genetic or environmental correlation coefficient is equal to one, genetic or environmental factors contributing to individual differences in personality endure across measurement points; when a genetic or environmental correlation coefficient is equal to zero, there is no overlap in them across the two time points. Previous studies investigating the genetic and environmental correlation with longitudinal adult twin samples showed that genetic rank-order stability is relatively high and environmental rank-order stability is lower (Blonigen et al., 2008; Bratko & Butkovic, 2007; Hopwood et al., 2011; Johnson et al., 2005; Kandler et al., 2010; Kandler, 2013; McGue et al., 1993; Viken et al., 1994). These studies have established strong evidence for a highly stable genetic foundation of individual differences in broad personality traits in adulthood.

In terms of the third issue, longitudinal twin studies have investigated the extent to which genetic and environ-

mental factors influence change and stability in personality. There are several studies that particularly examined the genetic and environmental foundations of stability in personality traits, and that demonstrated the stability of personality in adulthood is due mainly to a firm genetic underpinning and partly to the stability of environmental influences (Bratko & Butkovic, 2007; Johnson et al., 2005; McGue et al., 1993). Additionally, more recent longitudinal twin studies have investigated the genetic and environmental contributions to personality change. For example, Hopwood et al. (2011) used latent growth modeling to show that the foundations of personality changes across young adulthood were explained by both genetic and non-shared environmental factors. Similar findings were reported by some studies (Bleidorn et al., 2009; Blonigen et al., 2008). However, there are some studies with longitudinal multiple-rater twin data (i.e., data including both self- and peer-reported personality) that offered slightly different findings; that is, that personality change is chiefly due to environmental factors (Bleidorn et al., 2012; Kandler et al., 2010). These recent studies, with some exceptions, insisted that both genetic and non-shared environmental factors influence personality development, although some earlier studies found genetic factors to affect rank-order stability in personality.

Although there are some studies focusing on personality change and stability in adulthood, as described above, such studies in childhood or adolescence are scarce. One of the previous studies with childhood or adolescent samples, De Fruyt et al. (2006), showed high stability in genetic influences and change in non-shared environmental influences on personality over a time period of three years from late childhood to early adolescence. Similar findings were obtained in a more recent study (Spengler et al., 2012). However, until the present, there have been no longitudinal twin studies with a sample from early to late adolescence. Therefore, this study aimed to fill a gap in the literature with a longitudinal twin study in adolescence.

Because the present study utilized two waves of longitudinal twin data, this study design addresses the first two issues about the genetic and environmental influences on personality development across adolescence. Specifically, this study first investigated whether heritability and environmentality of personality changes from early to late adolescence. Based on previous studies in children or young adults, we expected a similar heritability and environmentality as the preceding findings, characterized by roughly equal genetic and non-shared environmental influences. Then we examined change and stability in genetic and environmental influences on adolescent personality over time. Because the pattern of high stability in genetic influence and the relatively lower stability in environmental influence over time have been replicated by many previous studies using adult or child twin samples from different nations, and by employing different measures of personality, we can expect

a similar pattern of genetic and environmental factors with a Japanese adolescent sample.

Materials and Methods

Participants and Procedure

This study used archival data from students who entered a secondary school affiliated with the Faculty of Education, the University of Tokyo. The students in the school were invited to participate in the research after entering the school. The research began in 1950, and numerous educational, psychological, and physical indicators have been collected up to the present. In addition to other non-twin students, the school takes in approximately 10 –20 twin pairs every year, and many variables from the twin students have been gathered. Personality indicators of the twin students were collected from 1981 to 2010 and were assembled as part of the archival data.

The archival data used in this study include 321 same-sex twin pairs (180 female twins). The analyses presented here were carried out on all twins participating in the study (273 MZ twin pairs and 48 DZ twin pairs). Approximately 45% of the total, 146 twins (121 MZ twin pairs and 25 DZ twin pairs), completed the questionnaire approximately three years later ($M = 3.2$, $SD = 0.66$, range 2–4 years). The age range varied from 12 to 14 years ($M = 12.7$; SD 1 0.59) at the first time point, and from 15 to 17 years ($M = 15.8$; $SD = 0.74$) at the second time point.

Zygosity diagnosis was conducted at school entry. Approximately, 30 physiological indicators were checked by school physicians, including blood type, serum, uric acid level, cholesterol level, height, weight, and so forth.

Measure

The sample for this study was given the Yatabe-Guilford Personality Inventory (YGPI; Yatabe, 1975), which was developed in Japan, based on three Guilford–Martin inventories (Guilford, 1940; Guilford & Martin, 1943a, 1943b). The YGPI consists of 12 traits: Depression, Cyclic Tendency, Inferiority Feelings, Nervousness, Lack of Objectivity, Lack of Cooperativeness, Lack of Agreeableness, General Activity, Rhathymia, Thinking Extroversion, Ascendance, and Social Extroversion. *Depression* refers to the inclination to become gloomy and pessimistic and to have feelings of guilt. *Cyclic Tendency* describes the tendency to conspicuously change one's mood and to become emotionally unstable. *Inferiority Feelings* denotes a lack of confidence, uncomfortableness, and underestimation of oneself. *Nervousness* represents the tendency to become surprised, impatient with trivial matters, and restless. *Lack of Objectivity* indicates the inclination to refer everything to oneself, to be sensitive to criticism, and to become easily confused. *Lack of Cooperativeness* describes the inclination to suspect others, to dislike successful people, and to have a belief that people are dishonest. *Lack of Agreeableness* represents the tendency to hate to lose, to be

selfish, and to quarrel with others. *General Activity* denotes the tendency to be lively and eager. *Rhathymia* describes the tendency to be easygoing, lighthearted, and happy. *Thinking Extroversion* indicates the tendency to not pay attention to details and to take one's failures quite easily. *Ascendance* refers to social dominance and social leaderships. *Social Extroversion* describes a social vitality and tendency to seek social relationships. Item examples of each YGPI scale are shown in the Appendix.

The 12 YGPI scales cover the Neuroticism and Extraversion domains of the Big Five personality inventory (Natsuno, 1998; Shimonaka, 1996). In this regard, the YGPI is similar to the Guilford–Zimmerman Temperament Survey (GZTS; Guilford et al., 1976). Shimonaka (1996) investigated correlations between the YGPI and the Revised NEO Personality Inventory (NEO-PI-R), and the results are also shown in the Appendix. The NEO-PI-R domains, especially Neuroticism and Extraversion, are correlated with some of the YGPI subscales.

The YGPI-12 scales have enough validity and reliability (Tsujioka, 2000). Cronbach's alpha reliability coefficients range from 0.70 to 0.92 ($Mdn = 0.85$), and test–retest reliability estimates among one-month for the 12 scales ranged from 0.56 to 0.82 ($Mdn = 0.73$; Tsujioka, 2000). All participants in the present study completed the YGPI at school. Each trait of the YGPI contains 10 items rated on a 3-point scale: 0 (no), 1 (yes and no), and 2 (yes). The score of each trait was calculated from the 10 items after dealing with the reverse scoring. The theoretical range of personality scores is from 0 to 20.

Data Analyses

Phenotypic analyses. Before all data analyses, the YGPI scores were standardized as *t* scores ($M = 50$, $SD = 10$). Phenotypic analyses were conducted on all available data. We first calculated correlations for the YGPI trait scores among co-twins and two time points. Then we analyzed mean-level changes in YGPI trait scores across adolescent years. These phenotypic analyses were conducted with R 3.1.0.

Biometric analyses. Genetic model fitting of twin data utilizes the difference in genetic similarity between MZ, who share 100% of their genetic material, and DZ twins, who share an average of 50% of their segregating genetic material, to index the relative genetic and environmental contributions to an observed phenotype. This analytic method typically decomposes the variance of a phenotype into three components: additive genetic effects (a^2), shared environmental effects (c^2), and non-shared environmental effects (e^2). The additive genetic effects describe the effect of multiple genes that have influence in a linear or additive fashion. The shared environments represent influences that are common to each member of a twin pair. The non-shared environments, including measurement error and state
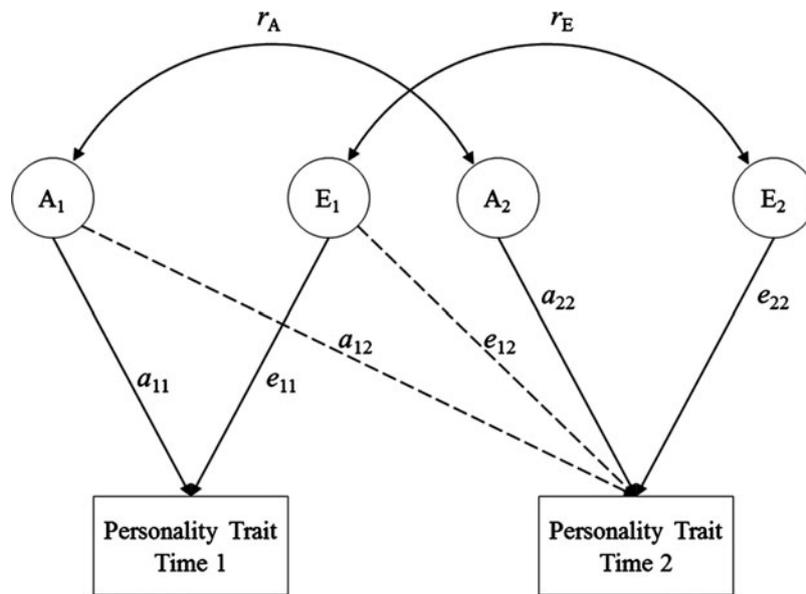
FIGURE 1

Path diagram of the Cholesky decomposition model. The variance of personality at each assessment is decomposed into additive genetic effects (A_1 and A_2) and non-shared environmental effects (E_1 and E_2). This path diagram represents only one twin in a pair (results are identical for the co-twin).

fluctuations, stand for influences that are unique to each member of a twin pair. This methodology is based on the equal environments assumption (EEA), which assumes that MZ pairs are no more likely to share the environmental events of etiologic importance for the phenotype under study than DZ pairs (Kendler et al., 1993). Thus, any differences in the MZ and DZ correlations are assumed to be attributed to differences in the genetic similarity of the corresponding twins.

To evaluate the origins of rank-order stability of personality, we fitted a Cholesky decomposition model. Within a Cholesky decomposition model (see Figure 1), the variance within and the covariance between personality traits across each assessment are split into their genetic and environmental components. The genetic, shared environmental, and non-shared environmental covariances can be standardized on their respective variances to produce genetic, shared environmental, and non-shared environmental correlations in this model. These statistics indicate the extent to which a particular effect at one assessment is correlated with the same effect at another assessment. A genetic correlation of 1.0 (i.e., $r_g = 1$) would mean that all genetic influences persist across assessments, whereas a correlation of zero would indicate no genetic overlap. Much the same is true of an environmental correlation. Thus, this model made it possible for us to specifically estimate the extent to which genetic and environmental influences contribute to the rank-order stability of personality over time. Cholesky models were fitted via maximum likelihood using Mplus version 7 (Muthén & Muthén, 2012).

When fitting a Cholesky model, variances, covariances, and means are freely estimated by minimizing the deviance statistic, minus twice the log-likelihood (-2l nL). The -2l nL under this unrestricted baseline model is compared with -2l nL under more restrictive biometric models. This comparison provides a likelihood-ratio χ^2 test of goodness of fit for the model. The model fit was assessed by χ^2 difference tests, Akaike Information Criterion (AIC; Akaike, 1974), Bayesian Information Criterion (BIC; Schwartz, 1978), and root-mean-square error of approximation (RMSEA; cf. Hu & Bentler, 1999). The lower χ^2 values, the more negative AIC and BIC (AIC = χ^2 – 2df; BIC = χ^2 – $k$ln[n]) values, and the lower RMSEA, suggesting a better fit.

Results

Attrition Analyses

Almost 45% of the Time 1 participants completed the questionnaires at Time 2 in the present study. Attrition effects were inspected for split samples by comparing mean age, gender, zygosity, and personality scores at Time 1 between participants (MZ and DZ twins) who completed the YGPI at both assessments (MZ, $N = 121$; DZ, $N = 25$) and those who completed it at Time 1 but did not take part at the next assessment (MZ, $N = 152$; DZ, $N = 23$). For demographic variables, we found no differences in zygosity ($\chi^2 = 0.79$, $df = 1$, $p = .38$), and gender ($\chi^2 = 0.60$, $df = 1$, $p = .44$). However, a small difference in mean age was observed ($t = 2.63$, $df = 249.9$, $p = .009$, Cohen's $d = 0.30$), which shows

TABLE 1

Twin Correlations for the YGPI Traits and Two Time Points

	Monozygotic twins			Dizygotic twins		
YGPI Scales	Time 1 Twin 1	Time 1 Twin 2	Time 2 Twin 1	Time 1 Twin 1	Time 1 Twin 2	Time 2 Twin 1
Depression						
Time 1 Twin 2	0.35 [0.23, 0.45]			0.12 [-0.17, 0.40]		
Time 2 Twin 1	**0.47 [0.31, 0.60]**	0.27 [0.09, 0.43]		**0.36 [-0.05, 0.67]**	0.09 [-0.33, 0.47]	
Time 2 Twin 2	0.40 [0.23, 0.54]	**0.55 [0.41, 0.67]**	0.53 [.38, 0.65]	-0.08 [-0.48, 0.34]	**0.43 [0.03, 0.71]**	0.15 [-0.28, 0.53]
Cyclic tendency						
Time 1 Twin 2	0.31 [0.19, 0.41]			0.16 [-0.13, 0.43]		
Time 2 Twin 1	**0.47 [0.32, 0.60]**	0.39 [0.23, 0.54]		**0.31 [-0.11, 0.63]**	0.28 [-0.14, 0.62]	
Time 2 Twin 2	0.33 [0.16, 0.49]	**0.58 [0.44, 0.69]**	0.46 [0.31, 0.60]	0.10 [-0.32, 0.49]	**0.80 [0.59, 0.91]**	0.41 [0.00, 0.71]
Inferiority feelings						
Time 1 Twin 2	0.38 [0.27, 0.48]			0.25 [-0.04, 0.50]		
Time 2 Twin 1	**0.51 [0.36, 0.63]**	0.45 [0.29, 0.58]		**0.67 [0.36, 0.84]**	0.35 [-0.06, 0.66]	
Time 2 Twin 2	0.42 [0.25, 0.56]	**0.63 [0.51, 0.73]**	0.59 [0.45, 0.69]	0.37 [-0.05, 0.68]	**0.55 [0.18, 0.78]**	0.29 [-0.14, 0.63]
Nervousness						
Time 1 Twin 2	0.32 [0.21, 0.43]			0.11 [−0.18, 0.38]		
Time 2 Twin 1	**0.52 [0.37, 0.64]**	0.40 [0.23, 0.54]		**0.39 [-0.01, 0.69]**	0.17 [-0.25, 0.54]	
Time 2 Twin 2	0.39 [0.22, 0.54]	**0.55 [0.41, 0.67]**	0.52 [0.38, 0.65]	-0.12 [-0.51, 0.31]	**0.58 [0.24, 0.80]**	0.05 [-0.37, 0.45]
Lack of objectivity						
Time 1 Twin 2	0.33 [0.21, 0.43]			0.09 [-0.21, 0.36]		
Time 2 Twin 1	**0.48 [0.32, 0.61]**	0.30 [0.12, 0.46]		**0.62 [0.29, 0.82]**	0.19 [-0.23, 0.55]	
Time 2 Twin 2	0.33 [0.16, 0.49]	**0.58 [0.45, 0.69]**	0.44 [0.28, 0.58]	0.21 [-0.22, 0.57]	**0.35 [-0.06, 0.66]**	0.10 [-0.33, 0.49]
Lack of cooperativeness						
Time 1 Twin 2	0.45 [0.35, 0.54]			0.36 [0.08, 0.58]		
Time 2 Twin 1	**0.56 [0.42, 0.67]**	0.38 [0.21, 0.52]		**0.44 [0.04, 0.72]**	0.05 [-0.36, 0.45]	
Time 2 Twin 2	0.26 [0.08, 0.42]	**0.36 [0.19, 0.51]**	0.43 [0.27, 0.57]	0.40 [-0.02, 0.70]	**0.53 [0.16, 0.77]**	0.33 [-0.10, 0.65]
Lack of agreeableness						
Time 1 Twin 2	0.31 [0.19, 0.41]			0.19 [-0.10, 0.45]		
Time 2 Twin 1	**0.47 [0.31, 0.60]**	0.21 [0.03, 0.38]		**0.68 [0.38, 0.85]**	0.11 [-0.30, 0.49]	
Time 2 Twin 2	0.21 [0.02, 0.38]	**0.41 [0.24, 0.55]**	0.40 [0.24, 0.55]	0.14 [-0.29, 0.52]	**0.29 [-0.13, 0.62]**	0.22 [-0.21, 0.58]
General activity						
Time 1 Twin 2	0.35 [0.24, 0.45]			0.13 [-0.16, 0.40]		
Time 2 Twin 1	**0.49 [0.34, 0.62]**	0.29 [0.11, 0.45]		**0.63 [0.30, 0.82]**	0.20 [-0.22, 0.56]	
Time 2 Twin 2	0.40 [0.23, 0.55]	**0.59 [0.46, 0.70]**	0.34 [0.16, 0.49]	0.06 [-0.36, 0.46]	**0.49 [0.11, 0.74]**	0.26 [-0.17, 0.61]
Rhathymia						
Time 1 Twin 2	0.42 [0.31, 0.52]			0.11 [-0.18, 0.39]		
Time 2 Twin 1	**0.47 [0.31, 0.60]**	0.25 [0.07, 0.41]		**0.79 [0.57, 0.90]**	-0.20 [-0.49, 0.20]	
Time 2 Twin 2	0.17 [-0.01, 0.34]	**0.45 [0.29, 0.59]**	0.31 [0.14, 0.47]	0.07 [-0.35, 0.47]	**0.42 [0.02, 0.70]**	0.13 [-0.30, 0.51]
Thinking extroversion						
Time 1 Twin 2	0.29 [0.17, 0.39]			0.23 [-0.06, 0.49]		
Time 2 Twin 1	**0.44 [0.28, 0.57]**	0.19 [0.01, 0.36]		**0.26 [-0.16, 0.60]**	-0.18 [-0.55, 0.24]	
Time 2 Twin 2	0.09 [-0.10, 0.27]	**0.32 [0.15, 0.48]**	0.21 [0.02, 0.38]	0.36 [-0.07, 0.67]	**0.51 [0.14, 0.76]**	0.35 [-0.08, 0.66]
Ascendance						
Time 1 Twin 2	0.55 [0.45, 0.63]			0.16 [-0.13, 0.43]		
Time 2 Twin 1	**0.57 [0.43, 0.68]**	0.45 [0.29, 0.58]		**0.73 [0.46, 0.87]**	0.04 [-0.37, 0.43]	
Time 2 Twin 2	0.43 [0.27, 0.57]	**0.66 [0.54, 0.75]**	0.56 [0.42, 0.67]	-0.10 [-0.49, 0.33]	**0.71 [0.42, 0.86]**	0.28 [-0.15, 0.62]
Social extroversion						
Time 1 Twin 2	0.53 [0.43, 0.61]			0.29 [0.00, 0.53]		
Time 2 Twin 1	**0.59 [0.46, 0.70]**	0.35 [0.18, 0.50]		**0.77 [0.54, 0.90]**	0.20 [-0.23, 0.55]	
Time 2 Twin 2	0.44 [0.28, 0.58]	**0.60 [0.47, 0.71]**	0.48 [0.32, 0.61]	0.21 [-0.22, 0.57]	**0.49 [0.11, 0.75]**	0.47 [0.07, 0.74]

Note: 95% confidence intervals are shown in parentheses. Rank-order stability coefficients are presented in bold type. YGPI = Yatabe-Guilford Personality Inventory.

that the mean age of participants who completed the YGPI at both times was slightly lower. Uncorrected for multiple testing effects, no differences were revealed in each YGPI scale for both co-twins (-1.58 < ts < 1.37, ps > .115). Therefore, the twins who participated in both assessments in this study did not substantively differ from the other twins who took part in only the first assessment, except for their mean age.

Phenotypic Results

Rank-order stability and twin intraclass correlation. Rank-order stability coefficients of longitudinal twin data

and twin intraclass correlation coefficients are reported in Table 1. Results showed moderate stability of the YGPI scores among adolescent years. Because of the small sample size of DZ twins, the estimates of rank-order stability coefficients of DZ twins varied widely. The magnitude of rank-order stability was not substantially different across MZ and DZ twins.

Mean-level change. For an illustration of change in mean-levels of the YGPI scales, averaged t scores were calculated on data from participants who completed the YGPI twice. Results showed that moderate mean-level

TABLE 2

Mean-Level Change and Stability in the YGPI Scales

YGPI scales	Time 1		Time 2		
	M	SD	M	SD	d*
Depression	49.06	9.66	52.01	10.36	1.11
Cyclic tendency	49.59	9.76	50.91	10.44	0.51
Inferiority feelings	49.70	9.75	50.65	10.45	0.38
Nervousness	49.35	9.87	51.38	10.10	0.75
Lack of objectivity	49.83	9.91	50.43	10.17	0.13
Lack of cooperativeness	49.96	9.77	50.10	10.43	0.10
Lack of agreeableness	49.51	9.98	51.00	9.96	0.68
General activity	49.91	9.68	50.23	10.66	0.19
Rhathymia	50.01	9.82	49.95	10.36	0.04
Thinking extroversion	50.66	10.03	48.62	9.75	0.81
Ascendance	50.20	9.78	49.57	10.45	0.26
Social extroversion	50.34	9.74	49.33	10.48	0.36

Note: d = estimated effect size for Cohen's d paired measurements: $tc[2(1-r)/n]^{1/2}$, in which $tc = M_{diff}/(SD_{diff}/n)^{1/2}$ (Dunlap et al., 1996). YGPI = Yatabe-Guilford Personality Inventory.

changes were observed in seven YGPI traits: Depression, Cyclic Tendency, Inferiority Feelings, Nervousness, Lack of Agreeableness, Thinking Extroversion, and Social Extroversion (see Table 2).

Biometric Results

Longitudinal Genetic Analyses. Based on the obtained pattern of MZ–DZ correlations shown in Table 1, the first tested model included A, C, and E. Compared between longitudinal Cholesky decomposition models by χ^2 tests and other model-fit indices, the AE model, including additive genetic and non-shared environmental effects, was the best fit for all YGPI scales. Detailed results of model fittings are given in Table 3. Thus, we showed the parameter estimates of AE models (Figure 1) for each YGPI scale. The detailed estimates are presented in Table 4. Heritability estimates obtained from the bivariate genetic analyses ranged from 0.27 (for *Thinking Extroversion* at Time 1) to 0.62 (for *Ascendance* at Time 2). Estimates of genetic and environmental correlation coefficients for each YGPI scale reveal if genetic or environmental influences contribute to stability or change in personality in the period from early to late adolescence. Genetic correlation coefficients (*Mdn* = 0.74) ranged between 0.62 (for *Thinking Extroversion*) to 0.83 (for *Nervousness*) and environmental correlations (*Mdn* = 0.31) ranged from 0.26 (for *Lack of Cooperativeness*) to 0.35 (for *Rhathymia*). These estimates indicate that genetic influences on individual differences highly persist across measurement points and that those from environment moderately change over time.

Discussion

This study extends the research on personality development by examining genetic and environmental contributions to rank-order stability in adolescent personality traits. The strengths of this study were the use of a relatively rare

Japanese sample and the filling of a gap in the literature with a longitudinal twin study in adolescence. The limitations of this study are the use of a single, self-reported questionnaire to measure adolescent personality; the Japanese domestic questionnaire, YGPI; the small sample size, especially the number of DZ twin pairs; and the small number of measurements of personality. It has been indicated that there are stable individual differences in self-report response styles (McCrae & Costa, 2008), and it is also well known that mono-rater measures of personality constructs are susceptible to random and systematic error components (Campbell & Fiske, 1959). To control for these biases, it is effective to use additional measurement methods or independent ratings by well-informed observers (Hofstee, 1994; Kandler et al., 2010). Indeed, some previous studies have obtained reasonable findings regarding personality development through the use of self- and peer-reported personality scores (Bleidorn et al., 2012; Kandler et al., 2010, 2013). Future research should investigate adolescent personality development with multiple-method or multiple-rater personality data to reduce random and systematic error effects. Moreover, the small number of assessment times was also a limitation of this study. We could not analyze genetic and environmental effect on mean-level change and stability in personality because the sample was composed of individuals with only one or two waves of longitudinal data. Future research should collect longitudinal data from three or more assessments, resulting in the further investigation of individual differences in personality development across adolescence.

Despite these limitations, this study obtained significant results. Results of the bivariate Cholesky decomposition model analyses showed that additive genetic and non-shared environmental influences explain the variances of each YGPI scale and that the heritability was approximately 40%, which is consistent with previous studies (De Fruyt et al., 2006; Spengler et al., 2012) and supports the hypotheses of this study. Results of the bivariate analyses also showed that the rank-order stability of personality traits across adolescence are mainly due to high genetic rank-order stability, which agrees with previous studies dealing with samples after emerging adulthood (Blonigen et al., 2008; Bratko & Butkovic, 2007; Hopwood et al., 2011; Johnson et al., 2005; Kandler et al., 2010, 2013; McGue et al., 1993; Viken et al., 1994) and also supports the hypotheses of the present study.

Adolescent Personality Development: Results From Phenotypic Analyses

Although the sample size of this study was small; we obtained some phenotypic results that offer valuable insight to prior inconsistent findings. Mean-level changes in the YGPI scales were examined by differences in the YGPI scale scores between times. The results showed large increases

TABLE 3

Results of Longitudinal Cholesky Decomposition Model Fitting for the YGPI Scales

YGPI scales	-2lnL	$\Delta\chi^2$	Δdf	p	AIC	BIC	RMSEA	90%CI
Depression								
Full model	7147.07							
ACE	7171.10	24.03	17	0.12	7193.10	7234.58	0.05	[0.00, 0.09]
AE	7171.10	0.00	3	1.00	7187.10	7217.27	0.04	[0.00, 0.08]
CE	7179.13	8.03	3	0.05	7195.13	7225.30	0.06	[0.01, 0.10]
Cyclic tendency								
Full model	6766.91							
ACE	6789.39	22.49	17	0.17	6811.40	6852.88	0.05	[0.00, 0.09]
AE	6790.78	1.39	3	0.71	6806.78	6836.95	0.04	[0.00, 0.08]
CE	6791.30	1.90	3	0.59	6807.30	6837.47	0.04	[0.00, 0.08]
Inferiority feelings								
Full model	6339.74							
ACE	6353.80	14.06	17	0.66	6375.80	6417.28	0.00	[0.00, 0.06]
AE	6354.58	0.78	3	0.85	6370.58	6400.75	0.00	[0.00, 0.05]
CE	6356.23	2.44	3	0.49	6372.23	6402.40	0.00	[0.00, 0.05]
Nervousness								
Full model	6763.01							
ACE	6782.06	19.05	17	0.33	6804.06	6845.55	0.03	[0.00, 0.08]
AE	6782.31	0.25	3	0.97	6798.31	6828.48	0.00	[0.00, 0.07]
CE	6794.94	12.88	3	0.00	6810.94	6841.11	0.06	[0.01, 0.10]
Lack of objectivity								
Full model	6795.35							
ACE	6808.78	13.44	17	0.71	6830.79	6872.27	0.00	[0.00, 0.06]
AE	6808.78	0.00	3	1.00	6824.79	6854.96	0.00	[0.00, 0.04]
CE	6814.97	6.18	3	0.10	6830.97	6861.14	0.00	[0.00, 0.07]
Lack of cooperativeness								
Full model	6712.24							
ACE	6736.05	23.82	17	0.12	6758.05	6799.54	0.05	[0.00, 0.09]
AE	6736.06	0.01	3	1.00	6752.06	6782.24	0.04	[0.00, 0.08]
CE	6748.79	12.73	3	0.01	6764.79	6794.96	0.07	[0.03, 0.11]
Lack of agreeableness								
Full model	6795.95							
ACE	6810.40	14.45	17	0.63	6832.40	6873.89	0.00	[0.00, 0.06]
AE	6810.63	0.23	3	0.97	6826.63	6856.80	0.00	[0.00, 0.05]
CE	6811.62	1.22	3	0.75	6827.62	6857.80	0.00	[0.00, 0.05]
General activity								
Full model	6802.40							
ACE	6809.53	7.13	17	0.98	6831.53	6873.01	0.00	[0.00, 0.00]
AE	6810.65	1.12	3	0.77	6826.65	6856.82	0.00	[0.00, 0.00]
CE	6813.06	3.54	3	0.32	6829.06	6859.23	0.00	[0.00, 0.00]
Rhathymia								
Full model	7171.02							
ACE	7201.03	30.01	17	0.03	7223.03	7264.52	0.07	[0.02, 0.11]
AE	7201.93	0.90	3	0.83	7217.93	7248.10	0.06	[0.00, 0.10]
CE	7211.92	10.89	3	0.01	7227.92	7258.09	0.08	[0.05, 0.12]
Thinking extroversion								
Full model	6417.67							
ACE	6452.60	34.93	17	0.01	6474.60	6516.09	0.08	[0.04, 0.12]
AE	6453.28	0.68	3	0.88	6469.29	6499.46	0.07	[0.03, 0.11]
CE	6460.94	8.34	3	0.04	6476.94	6507.11	0.09	[0.05, 0.13]
Ascendance								
Full model	7040.70							
ACE	7063.76	23.07	17	0.15	7085.76	7127.25	0.05	[0.00, 0.09]
AE	7066.20	2.44	3	0.49	7082.20	7112.38	0.04	[0.00, 0.08]
CE	7076.73	12.96	3	0.00	7092.73	7122.90	0.07	[0.03, 0.11]
Social extroversion								
Full model	6292.99							
ACE	6307.87	14.88	17	0.60	6329.88	6371.36	0.00	[0.00, 0.06]
AE	6310.22	2.34	3	0.50	6326.22	6356.39	0.00	[0.00, 0.06]
CE	6315.03	7.15	3	0.07	6331.03	6361.20	0.03	[0.00, 0.07]

in *Depression, Cyclic Tendency, Nervousness*, and *Lack of Agreeableness*, and large decline in *Thinking Extroversion* ($ds > 0.50$). These results indicated that adolescents become more neurotic. Moreover, there were small differences in the *Inferiority Feelings, Ascendance*, and *Social Extroversion* over time (approximately $ds = 0.30$). *Ascendance* refers to one of the facets of Extraversion, social dominance, and *Social*

Extroversion denotes the other facet of Extraversion, sociability. The differences in mean levels of *Ascendance*, and *Social Extroversion* over time implied declines in Extraversion across adolescence.

These results are roughly comparable with studies by Soto et al. (2011) and Van den Akker (2014). However, it should be noted that these phenotypic results were

TABLE 4

Parameter Estimates for the Longitudinal Cholesky Decomposition Model

YGPI scales	A at Time 1	A at Time 2	E at Time 1	E at Time 2	A^2	E^2	r_g	r_e
Depression								
Time 1	0.63		0.78		0.40	0.61		
	[0.54, 0.72]		[0.71, 0.85]		[0.28, 0.51]	[0.49, 0.72]		
Time 2	0.43	0.52	0.25	0.69	0.46	0.54	0.64	0.34
	[0.26, 0.60]	[0.39, 0.66]	[0.12, 0.38]	[0.61, 0.77]	[0.34, 0.58]	[0.43, 0.66]	[0.41, 0.86]	[0.17, 0.50]
Cyclic tendency								
Time 1	0.61		0.79		0.38	0.62		
	[0.52, 0.71]		[0.72, 0.86]		[0.27, 0.49]	[0.51, 0.73]		
Time 2	0.53	0.37	0.20	0.74	0.42	0.58	0.82	0.26
	[0.37, 0.69]	[0.17, 0.58]	[0.06, 0.34]	[0.66, 0.81]	[0.30, 0.54]	[0.46, 0.70]	[0.60, 1.00]	[0.08, 0.44]
Inferiority feelings								
Time 1	0.62		0.79		0.38	0.62		
	[0.53, 0.71]		[0.72, 0.85]		[0.28, 0.49]	[0.51, 0.72]		
Time 2	0.58	0.45	0.23	0.64	0.54	0.46	0.79	0.34
	[0.44, 0.73]	[0.29, 0.61]	[0.11, 0.35]	[0.57, 0.71]	[0.44, 0.64]	[0.36, 0.56]	[0.62, 0.96]	[0.17, 0.50]
Nervousness								
Time 1	0.59		0.81		0.35	0.66		
	[0.49, 0.68]		[0.74, 0.88]		[0.23, 0.46]	[0.54, 0.77]		
Time 2	0.59	0.40	0.20	0.67	0.51	0.50	0.83	0.28
	[0.43, 0.75]	[0.19, 0.61]	[0.08, 0.32]	[0.59, 0.75]	[0.39, 0.62]	[0.38, 0.61]	[0.63, 1.00]	[0.12, 0.45]
Lack of objectivity								
Time 1	0.61		0.79		0.37	0.63		
	[0.52, 0.70]		[0.72, 0.86]		[0.26, 0.48]	[0.52, 0.74]		
Time 2	0.47	0.46	0.24	0.72	0.43	0.58	0.72	0.31
	[0.31, 0.62]	[0.30, 0.61]	[0.12, 0.36]	[0.64, 0.80]	[0.31, 0.54]	[0.46, 0.69]	[0.50, 0.93]	[0.16, 0.46]
Lack of cooperativeness								
Time 1	0.74		0.67		0.55	0.45		
	[0.68, 0.80]		[0.60, 0.74]		[0.46, 0.64]	[0.36, 0.54]		
Time 2	0.39	0.50	0.21	0.75	0.40	0.60	0.62	0.26
	[0.25, 0.53]	[0.37, 0.62]	[0.07, 0.34]	[0.67, 0.83]	[0.28, 0.52]	[0.48, 0.72]	[0.42, 0.82]	[0.10, 0.43]
Lack of agreeableness								
Time 1	0.59		0.81		0.35	0.65		
	[0.49, 0.68]		[0.74, 0.88]		[0.23, 0.46]	[0.54, 0.77]		
Time 2	0.39	0.49	0.24	0.74	0.39	0.61	0.63	0.30
	[0.22, 0.57]	[0.34, 0.63]	[0.11, 0.36]	[0.67, 0.82]	[0.27, 0.51]	[0.49, 0.73]	[0.38, 0.88]	[0.15, 0.46]
General activity								
Time 1	0.63		0.77		0.40	0.60		
	[0.55, 0.72]		[0.70, 0.84]		[0.29, 0.51]	[0.49, 0.71]		
Time 2	0.51	0.36	0.22	0.75	0.39	0.61	0.82	0.28
	[0.36, 0.66]	[0.17, 0.56]	[0.09, 0.34]	[0.67, 0.83]	[0.27, 0.51]	[0.49, 0.73]	[0.61, 1.00]	[0.12, 0.43]
Rhathymia								
Time 1	0.65		0.76		0.42	0.58		
	[0.57, 0.74]		[0.69, 0.83]		[0.31, 0.53]	[0.47, 0.69]		
Time 2	0.44	0.49	0.27	0.71	0.43	0.57	0.67	0.35
	[0.28, 0.59]	[0.36, 0.62]	[0.15, 0.38]	[0.63, 0.79]	[0.31, 0.55]	[0.46, 0.69]	[0.46, 0.87]	[0.21, 0.49]
Thinking extroversion								
Time 1	0.52		0.86		0.27	0.74		
	[0.40, 0.63]		[0.79, 0.93]		[0.11, 0.39]	[0.58, 0.86]		
Time 2	0.36	0.46	0.22	0.78	0.35	0.65	0.62	0.27
	[0.14, 0.58]	[0.29, 0.64]	[0.09, 0.35]	[0.70, 0.86]	[0.22, 0.48]	[0.52, 0.78]	[0.27, 0.97]	[0.11, 0.42]
Ascendance								
Time 1	0.74		0.67		0.55	0.45		
	[0.68, 0.80]		[0.61, 0.74]		[0.46, 0.64]	[0.36, 0.54]		
Time 2	0.61	0.49	0.21	0.59	0.62	0.38	0.78	0.33
	[0.50, 0.72]	[0.38, 0.61]	[0.11, 0.31]	[0.52, 0.65]	[0.53, 0.71]	[0.30, 0.47]	[0.66, 0.90]	[0.18, 0.48]
Social extroversion								
Time 1	0.74		0.67		0.55	0.45		
	[0.68, 0.80]		[0.60, 0.74]		[0.46, 0.64]	[0.36, 0.54]		
Time 2	0.56	0.48	0.22	0.63	0.55	0.45	0.76	0.33
	[0.45, 0.68]	[0.36, 0.60]	[0.12, 0.33]	[0.56, 0.71]	[0.45, 0.65]	[0.35, 0.55]	[0.63, 0.90]	[0.18, 0.48]

Note: A = additive genetic effect, E = non-shared environmental effect, r_g = genetic correlation between two time points, r_e = environmental correlation between two time points, 95% confidence intervals are shown in parentheses.

obtained from same-sex twins. Watzlawik (2009) argued that MZ twins focused more on the internal differences, such as personality, during adolescence. Perhaps developmental trajectories of adolescent personality may be slightly different between twins and non-twins. We should, there-fore, further investigate whether the obtained phenotypic results were unique to twins. And, if so, future research should examine whether personality development is unique in twin adolescents who grow up with siblings similar with themselves.

Heritability and Environmentality of Adolescent Personality

The first research theme of this study was the relative contributions of genetic and environmental influences on individual differences in personality. The obtained results indicated that both effects remain stable across adolescence. Although previous studies focusing on adult samples suggested slight but significant decreases in heritability throughout the adult life span (e.g., Kandler et al., 2010; Viken et al., 1994), this study did not observe a significant decrease in heritability from 12 to 17 years age. However, it has been indicated that internalizing problems, especially depression and anxiety, change etiologic structures from childhood to young adulthood and that genetic contributions to childhood depression are different from those in adolescent or adult depression (Waszczuk et al., 2014). Based on these findings, it remains possible that the heritability and environmentality of Neuroticism-related traits change from childhood to adolescence. Future research should examine the heritability of personality traits with a younger sample, to fill a gap in the literature with a longitudinal behavior genetic study of personality traits.

Rank-Order Stability in Genetic Influences

The causes of rank-order stability in personality were the second research theme of this study. Consistent with previous studies, the present study showed high rank-order stability of genetic factors. Indeed, we observed the three-year stability of genetic influences was approximately $r_g = 0.70$ and that of environmental effects was approximately $r_e = 0.30$. These estimates are nearly identical to the previous studies focused on similar age groups (e.g., Bratko & Butkovic, 2007; Viken et al., 1994). These results mean that a large part of genetic factors influencing personality traits in early adolescence also contribute to those in late adolescence. In contrast, there is a substantial change in non-shared environmental influences. These reproducible results have enormous importance for personality development research.

It is also worth noting that these results denote the same tendency of each YGPI scale. The YGPI scales cover the Neuroticism and Extraversion domains (Natsuno, 1998; Shimonaka, 1996); however, the observed genetic and environmental correlations were almost the same as each other. For example, Bratko and Butkovic (2007) showed similar results on the Eysenck Personality Questionnaire (Eysenck & Eysenck, 1975) scales, except for the lie scale. De Fruyt et al. (2006) and Spengler et al. (2012) also suggested similar results on Big Five personality traits, except for Openness. Based on these findings, we can say that the genetic factors contributing to at least Neuroticism and Extraversion remain equally stable and that the results of this study supported these findings.

However, the results of the Cholesky model analyses showed not only genetic stability in personality but also the

novel genetic influences after mid-adolescence, despite the small proportion of total variance. Previous studies revealed that genetic effects on anxiety, depression and behavioral problems varied over the adolescent years through genetic innovation (Kendler et al., 2008; Lewis & Plomin, 2015); the results of the present study are consistent with these findings. Although the details of the genetic innovation are unclear, they may be attributable to unique physical changes during adolescence. Juvenile physical changes, including the onset of puberty or brain maturation, are highly genetically determined (e.g., Chiang et al., 2011; Silventoinen et al., 2008). It has been suggested that these physical changes may have effects on emotional instability and Extraversion (e.g., Blankstein et al., 2009; Mensah et al., 2013). In fact, an association between personality and physical change has been shown; changes in Conscientiousness, Extraversion, and Neuroticism were significantly associated with changes in mental and physical health status (Magee et al., 2013). Therefore, future research should explore the specific genes related to this genetic innovation and investigate the mutual trajectories of personality and physical development across adolescence.

Acknowledgments

References

Akaike, H. (1974). A new look at the statistical model identification. *IEEE Transactions on Automatic Control*, *19*, 716–723.

Allik, J., Laidra, K., Realo, A., & Pullmann, H. (2004). Personality development from 12 to 18 years of age: Changes in mean levels and structure of traits. *European Journal of Personality*, *18*, 445–462.

Blankstein, U., Chen, J. Y. W., Mincic, A. M., McGrath, P. A., & Davis, K. D. (2009). The complex minds of teenagers: Neuroanatomy of personality differs between sexes. *Neuropsychologia*, *47*, 599–603.

Bleidorn, W., Kandler, C., & Caspi, A. (2014). The behavioural genetics of personality development in adulthood—classic, contemporary, and future trends. *European Journal of Personality*, *28*, 244–255.

Bleidorn, W., Kandler, C., Riemann, R., Angleitner, A., & Spinath, F. M. (2009). Patterns and sources of adult personality development: Growth curve analyses of the NEO-PI-R scales in a longitudinal twin study. *Journal of Personality and Social Psychology*, *97*, 142–155.

Bleidorn, W., Kandler, C., Riemann, R., Angleitner, A., & Spinath, F. M. (2012). Genetic and environmental influences on personality profile stability: Unraveling the normativeness problem. *Journal of Personality*, *80*, 1029–1060.

Blonigen, D. M., Carlson, M. D., Hicks, B. M., Krueger, R. F., & Iacono, W. G. (2008). Stability and change in personality traits from late adolescence to early adulthood: A longitudinal twin study. *Journal of Personality, 76*, 229–266.

Branje, S. J. T., Van Lieshout, C. F. M., & Gerris, J. R. M. (2007). Big Five personality development in adolescence and adulthood. *European Journal of Personality, 21*, 45–62.

Bratko, D., & Butkovic, A. (2007). Stability of genetic and environmental effects from adolescence to young adulthood: Results of Croatian longitudinal twin study of personality. *Twin Research and Human Genetics, 10*, 151–157.

Campbell, D. T., & Fiske, D. W. (1959). Convergent and discriminant validation by the multitrait-multimethod matrix. *Psychological Bulletin, 56*, 81–105.

Canals, J., Vigil-Colet, A., Chico, E., & Martí-Henneberg, C. (2005). Personality changes during adolescence: The role of gender and pubertal development. *Personality and Individual Differences, 39*, 179–188.

Chiang, M. C., McMahon, K. L., de Zubicaray, G. I., Martin, N. G., Hickie, I., Toga, A. W., . . . & Thompson, P. M. (2011). Genetics of white matter development: A DTI study of 705 twins and their siblings aged 12 to 29. *NeuroImage, 54*, 2308–2317.

De Fruyt, F., Bartels, M., Van Leeuwen, K. G., De Clercq, B., Decuyper, M., & Mervielde, I. (2006). Five types of personality continuity in childhood and adolescence. *Journal of Personality and Social Psychology, 91*, 538–552.

Dunlap, W. P., Cortina, J. M., Vaslow, J. B., & Burke, M. J. (1996). Meta-analysis of experiments with matched groups or repeated measures designs. *Psychological Methods, 1*, 170–177.

Eysenck, H. J., & Eysenck, S. B. (1975). *Manual of the Eysenck Personality Questionnaire*. San Diego, CA: Educational and Industrial Testing Service.

Guilford, J. P. (1940). *An inventory of factors STDCR*. Beverly Hills, CA: Sheridan Supply Co.

Guilford, J. P., & Martin, H. G. (1943a). *The Guilford-martin inventory of factors GAMIN*. Beverly Hills, CA: Sheridan Supply Co.

Guilford, J. P., & Martin, H. G. (1943b). *Guilford-martin personnel inventory*. Beverly Hills, CA: Sheridan Supply Co.

Guilford, J. S., Zimmerman, W. S., & Guilford, J. P. (1976). *The guilford–zimmerman temperament survey handbook: Twenty-five years of research and application*. San Diego, CA: EdITS Publishers.

Hofstee, W. T. (1994). Who should own the definition of personality? *European Journal of Personality, 8*, 149–162.

Hopwood, C. J., Donnellan, M. B., Bloningen, D. M., Krueger, R. F., McGue, M., Iacono, W. G., . . . Burt, S. A. (2011). Genetic and environmental influences on personality trait stability and growth during the transistion to adulthood: A three-wave longitudinal study. *Journal of Personality and Social Psychology, 100*, 545–556.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*, 1–55.

John, O. P., Naumann, L. P., & Soto, C. J. (2008). Paradigm shift to the integrative big five trait taxonomy: History, measurement, and conceptual issues. In O. P. John, R. W. Robins, & L. A. Pervin (Eds.), *Handbook of personality: Theory and research* (3rd ed.; pp. 114–158). New York, NY: Guilford Press.

Johnson, W. (2008). Genetic and environmental processes contributing to personality stability and change. In F. J. Neyer & F. M. Spinath (Eds.), *Nature and nurture: New perspectives on an old debate* (pp. 103–125). Stuttgart: Lucius & Lucius.

Johnson, A. M., Vernon, P. A., & Feiler, A. R. (2008). Behavioral genetic studies of personality: An introduction and review of the results of 50+ years of research. In G. J. Boyle (Ed.), *The SAGE handbook of personality theory and assessment. Personality theories and models*. Vol. 1, (pp. 145–173). Los Angeles: Sage.

Johnson, W., McGue, M., & Krueger, R. F. (2005). Personality stability in late adulthood: A behavioral genetic analysis. *Journal of Personality, 73*, 523–551.

Kandler, C. (2012). Nature and nurture in personality development: The case of neuroticism and extraversion. *Current Directions in Psychological Science, 21*, 290–296.

Kandler, C., Bleidorn, W., Riemann, R., Spinath, F. M., Thiel, W., & Angleitner, A. (2010). Sources of cumulative continuity in personality: A longitudinal multiple-rater twin study. *Journal of Personality and Social Psychology, 98*, 995–1008.

Kandler, C., Riemann, R., & Angleitner, A. (2013). Patterns and sources of continuity and change of energetic and temporal aspects of temperament in adulthood: A longitudinal twin study of self-and peer reports. *Developmental Psychology, 49*, 1739–1753.

Kandler, C., Riemann, R., Spinath, F. M., & Angleitner, A. (2010). Sources of variance in personality facets: A multiple-rater twin study of self-peer, peer-peer, and self-self (dis-)agreement. *Journal of Personality, 78*, 1565–1594.

Kendler, K. S., Gardner, C. O., & Lichtenstein, P. (2008). A developmental twin study of symptoms of anxiety and depression: Evidence for genetic innovation and attenuation. *Psychological Medicine, 38*, 1567–1575.

Kendler, K. S., Neale, M. C., Kessler, R. C., Heath, A. C., & Eaves, L. J. (1993). A test of the equal-environment assumption in twin studies of psychiatric illness. *Behavior Genetics, 23*, 21–27.

Klimstra, T. A., Hale, W. W. III, Raaijmakers, Q. A. W., Branje, S. J. T., & Meeus, W. H. J. (2009). Maturation of personality in adolescence. *Journal of Personality and Social Psychology, 96*, 898–912.

Lamb, M. E., Chuang, S. S., Wessels, H., Broberg, A. G., & Hwang, C. P. (2002). Emergence and construct validation of the Big Five factors in early childhood: A longitudinal analysis of their ontogeny in Sweden. *Child Development, 73*, 1517–1524.

Lewis, G. J., & Plomin, R. (2015). Heritable influences on behavioural problems from early childhood to mid-adolescence: Evidence for genetic stability and innovation. *Psychological Medicine, 45*, 2171–2179. doi:10.1017/S0033291715000173

Magee, C. A., Heaven, P. C. L., & Miller, L. M. (2013). Personality change predicts self-reported mental and physical health. *Journal of Personality*, *81*, 324–334.

McCrae, R. R., & Costa, P. T., Jr. (2008). The five-factor theory of personality. In O. P. John, R. W. Robins & L. A. Pervin (Eds.), *Handbook of personality: Theory and research* (3rd ed., pp. 159–181). New York, NY: Guilford Press.

McCrae, R. R., Costa, P. T., Jr., Terracciano, A., Parker, W. D., Mills, C. J., De Fruyt, F., & Mervielde, I. (2002). Personality trait development from age 12 to age 18: Longitudinal, cross-sectional and cross-cultural analyses. *Journal of Personality and Social Psychology*, *83*, 1456–1468.

McGue, M., Bacon, S., & Lykken, D. T. (1993). Personality stability and change in early adulthood: A behavioral genetic analysis. *Developmental Psychology*, *29*, 96–109.

Mensah, F. K., Bayer, J. K., Wake, M., Carlin, J. B., Allen, N. B., & Patton, G. C. (2013). Early puberty and childhood social and behavioral adjustment. *Journal of Adolescent Health*, *53*, 118–124.

Muthén, L. K., & Muthén, B. (2012). *Mplus user's guide* (7th ed.). Los Angeles, CA: Muthén & Muthén.

Natsuno, R. (1998). The relationship between five-factor personality questionnaire and Yatabe-Guilford personality test. In H. Tsuji (Ed.), *Theory and practice of five-factor personality inventory* (pp. 156−162). Kyoto, Japan: Kitaoji Shobo.

Pullmann, H., Raudsepp, L., & Allik, J. (2006). Stability and change in adolescents' personality: A longitudinal study. *European Journal of Personality*, *20*, 447–459.

Roberts, B. W., & DelVecchio, W. F. (2000). The rank-order consistency of personality traits from childhood to old age: A quantitative review of longitudinal studies. *Psychological Bulletin*, *126*, 3–25.

Roberts, B. W., Walton, K. E., & Viechtbauer, W. (2006). Patterns of mean-level change in personality traits across the life course: A meta-analysis of longitudinal studies. *Psychological Bulletin*, *132*, 1–25.

Schwartz, G. (1978). Estimating the dimension of a model. *The Annals of Statistics*, *6*, 461–464.

Shimonaka, Y. (1996). *The development of Japanese Version of NEO-PI-R Personality Inventory* (Report of the Grant-in-Aid for Scientific Research No. 06610148). Tokyo: Ministry of Education, Science, Sports and Culture.

Silventoinen, K., Haukka, J., Dunkel, L., Tynelius, P., & Rasmussen, F. (2008). Genetics of pubertal timing and its associations with relative weight in childhood and adult height: The Swedish young male twins study. *Pediatrics*, *121*, e885–e891.

Soto, C. J., John, O. P., Gosling, S. D., & Potter, J. (2011). Age differences in personality traits from 10 to 65: Big Five domains and facets in a large cross-sectional sample. *Journal of Personality and Social Psychology*, *100*, 330–348.

Spengler, M., Gottschling, J, & Spinath, F. M. (2012). Personality in childhood — A longitudinal behavior genetic approach. *Personality and Individual Differences*, *53*, 411–416.

Tsujioka, Y. (2000). *New method of personality assessment.* Osaka, Japan: Nihon Shinri Test Kenkyusyo Inc.

Turkheimer, E., Pettersson, E., & Horn, E. E. (2014). A phenotypic null hypothesis for the genetics of personality. *Annual Review of Psychology*, *65*, 515–540.

Van den Akker, A. L., Deković, M., Asscher, J., & Prinzie, P. (2014). Mean-level personality development across childhood and adolescence: A temporary defiance of the maturity principle and bidirectional associations with parenting. *Journal of Personality and Social Psychology*, *107*, 736–750.

Viken, R. J., Rose, R. J., Kaprio, J., & Koskenvuo, M. (1994). A developmental genetic analysis of adult personality: Extraversion and neuroticism from 18 to 59 years of age. *Journal of Personality and Social Psychology*, *66*, 722–730.

Waszczuk, M. A., Zavos, H. M. S., Gregory, A. M., & Eley, T. C. (2014). The phenotypic and genetic structure of depression and anxiety disorder symptoms in childhood, adolescence, and young adulthood. *JAMA Psychiatry*, *71*, 905–916.

Watzlawik, M. (2009). The perception of similarities and differences among adolescent siblings: Identification and deidentification of twins and nontwins. *Journal of Adolescent Research*, *24*, 561–578.

Yatabe, J. (1975). Yatabe-Guilford personality test. In T. Okado (Ed.), *Psychological assessment: Basic foundations* (pp. 269–281). Tokyo, Japan: Kakinouchi Press.

Tetsuya Kawamoto and Toshihiko Endo

YGPI scales	NEO-PI-R Factor					Example items
	E	A	C	N	O	
Depression	-0.44	-0.15	-0.33	**0.68**	-0.06	I become unintentionally sad with some friends.
Cyclic tendency	-0.04	-0.15	-0.38	**0.70**	0.07	I am often distracted and my ideas cannot take shape.
Inferiority feelings	-0.37	-0.09	0.28	**0.75**	-0.22	I have a fear that I will fail.
Nervousness	-0.40	-0.23	-0.16	**0.72**	-0.11	I am encumbered by a small thing.
Lack of objectivity	-0.19	-0.13	-0.30	**0.53**	-0.24	I often feel agitated.
Lack of cooperativeness	-0.34	-0.33	-0.19	**0.55**	-0.24	I think most people neglect their duties when they are not watched.
Lack of agreeableness	0.36	-0.21	-0.09	0.20	0.28	I often find other people ridiculous.
General activity	**0.65**	0.27	0.42	-0.45	0.13	I briskly manage things.
Rhathymia	**0.67**	0.05	-0.23	0.00	0.21	I often play with my friends.
Thinking extroversion	0.37	0.19	-0.19	-0.40	-0.06	I am often in deep thought.
Ascendance	**0.71**	0.08	0.26	-0.41	0.21	I willingly take duties upon myself.
Social extroversion	**0.78**	0.16	0.13	-0.33	0.19	I like to associate with other people.

Note: YGPI = Yatabe-Guilford Personality Inventory; NEO-PI-R = Revised NEO Personality Inventory; E = Extraversion; A = Agreeableness; C = Conscientiousness; N = Neuroticism; O = Openness to experience. $N = 245$ (145 female). Correlations greater than ± 0.50 are shown in bold type.