Genetic and Environmental Covariations Among Obsessive–Compulsive Symptoms, Neuroticism, and Extraversion in South Korean Adolescent and Young Adult Twins

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A growing literature suggests that personality traits may be endophenotype markers for psychiatric illnesses. Although the phenotypic relationships between obsessive–compulsive disorder (OCD) and high neuroticism and low extraversion have been well documented, underlying genetic and environmental contributions to these associations have not been explored previously. Five hundred and twenty-four monozygoitc (MZ) and 228 dizygotic (DZ) pairs of adolescent and young adult twins (aged 13–24 years) drawn from the South Korean Twin Registry completed the Maudsley Obsessive Compulsive Inventory (MOCI) and the Neuroticism and Extraversion scale of the Eysenck Personality Scale by mail. The total score of MOCI (MOCIT) was significantly and positively correlated with Neuroticism (r = .44), but only weakly and negatively related to Extraversion (r = –.10). A trivariate Cholesky model was applied to the data. The additive genetic correlations in the best-fitting model were .51 between Neuroticism and MOCIT and –.17 between Extraversion and MOCIT, suggesting that additive genetic factors that lead to high neuroticism and low extraversion overlap with those genetic factors influencing high OC symptoms. These findings add to the cumulative evidence of the shared genetic etiology for the associations between a personality profile of high neuroticism and low extraversion and mental illnesses.

Keywords: obsessive–compulsive symptoms, neuroticism, extraversion, twins, genes, endophenotype

Obsessive–compulsive disorder (OCD) is characterized by symptoms of recurrent, distressing, unwanted thoughts, impulses, and images (obsessions) and ritualistic behaviors and mental acts (compulsions; American Psychiatric Association, 1994).

Prior studies have documented that as compared to healthy controls, patients with OCD tend to score higher in negative affects like neuroticism and harm avoidance and lower in positive affects like novelty seeking and extraversion (Alonso et al., 2008; Fullana et al., 2004; LaSalle-Ricci et al., 2006; Rector et al., 2002; Samuels et al., 2000; Wu et al., 2006). Although both OCD and personality traits have shown to be influenced by genetic as well as environmental factors (van Grootheest et al., 2005; Hur & Jeong, 2008), little is known about how genetic and environmental factors contribute to the associations between OCD and personality traits because multivariate twin studies have rarely been undertaken to examine this research issue. Recently, however, Ettelt et al. (2008) found that first-degree relatives of OCD patients were higher in harm avoidance than those of controls, indicating a possibility that familial factors play an important role in the covariation between OCD and harm avoidance.

Knowledge about the nature of the relationship between personality traits and psychiatric illnesses is important for clarification of the etiology of psychiatric illnesses as well as for possible prevention through identification of at-risk children early in life.

Using structural equation modeling, a number of twin studies have linked neuroticism and extraversion to mood and anxiety disorders (Bienvenu et al., 2007; Fanous et al., 2007; Hettema et al., 2006; Kendler et al., 2006). These studies have consistently reported that genetic correlations between neuroticism and anxiety and mood disorders are positive and high, while those between extraversion and mood and anxiety disorders are negative and weak. Environmental correlations between the two personality dimensions and mood and anxiety disorders have been shown to be relatively modest. These findings led researchers to conclude that high neuroticism and low extraversion may be genetic risk factors for the development of mood and anxiety disorders. As OCD is an anxiety disorder (American Psychiatric Association, 1994), it is possible that

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genetic factors for OCD overlap with those of neuroticism and extraversion.

Previously, obsessive–compulsive (OC) symptoms, neuroticism, and extraversion were shown to be significantly heritable in the South Korean population (Hur, 2007; Hur & Jeong, 2008). The main goal of the present study was therefore to explore whether OC symptoms share genetic and/or environmental etiologies with two major personality dimensions, i.e., neuroticism and extraversion.

Methods

Sample

The sample was drawn from the South Korean Twin Registry (SKTR; Hur et al., 2006). The SKTR is a volunteer registry of South Korean twins and their families. Twins' zygosity in the SKTR was determined from the twins' parents' responses to a zygosity questionnaire. When compared to the analysis of DNA markers, this questionnaire method has yielded over 90% accuracy in determining zygosity in Asian twin samples (Ooki et al., 1993). To maximize the accuracy in zygosity classification, however, 43 pairs of the twins whose zygosity was ambiguous were removed from our analyses.

In 2006, a mail survey including a Korean version of the Maudsley Obsessional-Compulsive Inventory (MOCI; Hodgson & Rachman, 1977) and Eysenck Personality Scale (EPS; Eysenck & Eysenck, 1991) was sent to adolescent and young adult twins registered with the SKTR who were residing in Seoul and three counties in South Korea. These areas were selected for the mail survey in 2006 because at the time of the survey, permissions for the participation in research had been obtained from the twins in these areas. The overall response rate of the mail survey in 2006 was approximately 32%.

The final sample included 752 pairs of the twins, consisting of 524 pairs of MZ (187 male and 337 female pairs) and 228 pairs of DZ twins (59 male, 65 female, and 104 opposite-sex pairs). The ages of the twins ranged from 13 to 24 years, with a mean of 17.5 years and a SD of 2.4 years. Consistent with twin birth rates in the South Korean population for the birth cohorts used in the present study (Hur & Kwon, 2005), the number of MZ twins was much greater than that of DZ twins. Males were underrepresented in the sample partly because some of the young adult male twins were at the military service at the time of the mail survey as South Korean young adult males are obliged to complete the army service.

Measures

Maudsley Obsessive Compulsive Inventory (MOCI). The Korean version of the MOCI included 30 true-false items designed to measure obsessive compulsive complaints (Shin et al., 2001) and was described in detail elsewhere (Hur & Jeong, 2008). In brief, the MOCI covers a broad range of OC symptoms such as checking and cleaning habits, slow repetitive behaviors, and serious doubts about simple daily activities. In the present study, the total score of the 30 items was used (hereafter, MOCIT), which represents an aggregate of various OC symptoms. The internal consistency reliability of the 30 items was .76. The MOCIT has been shown to reliably discriminate between obsessional patients and normals (Emmelkamp et al., 1999). Hodgson and Rachman (1977) showed that the mean score of the MOCIT was 18.86 (*SD* = 4.92) for the obsessional patients. The mean of the MOCIT was 9.51 (*SD* = 4.56) in the present sample.

Neuroticism and Extraversion. To measure neuroticism and extraversion, the Neuroticism and Extraversion scales from a Korean version of the Eysenck Personality Scale (EPS; Eysenck & Eysenck, 1991) were used. Each of these two scales included 12 items. Validity and reliabilities of the Korean version of the EPS have been well established (Lee, 1997). The internal consistency reliability estimates in the present sample were .80 for Neuroticism and .81 for Extraversion. Means (SDs) for Neuroticism and Extraversion in the present sample were 5.53 (± 3.20) and 7.06 (± 3.09), respectively.

Statistical Methods

To determine the causes of covariances among Extraversion, Neuroticism, and MOCIT, twin correlations and cross-twin cross-trait correlations for MZ and DZ twins were computed and model-fitting analyses were carried out. Correlations of age and sex with MOCIT, Extraversion, and Neuroticism were very small ($-.09 \leq r \leq .09$). Although univariate analyses have shown sex-specific genetic and environmental influences on MOCIT and Neuroticism (Finkel & McGue, 1997; Hur & Jeong, 2008), both sexes were combined in this multivariate analysis to maximize sample size.

A trivariate Cholesky model (Neale & Cardon, 1992) was applied to the data. In the full trivariate Cholesky model, each of the three Cholesky factors for Extraversion, Neuroticism, and MOCIT are decomposed into additive genetic factors (A), shared environmental factors (C), and individual specific environmental factors including measurement error (E). Nonadditive genetic factors were not included in the model because twin correlations suggested little effects of nonadditive genetic factors and because the sample size in the present sample was not sufficiently large to estimate nonadditive genetic factors. The first Cholesky factors (i.e., A_1, C_1, & E_1) exert influences on all three traits, that is, Extraversion, Neuroticism, and MOCIT, although they predominantly impact Extraversion. The second Cholesky factors (i.e., A_2, C_2, & E_2) have effects mainly on Neuroticism, although they influence MOCIT also. The third Cholesky factors (i.e., A_3, C_3, & E_3) are those unique to MOCIT. The A, C, and E covariance matrices were computed by the product of their respective Cholesky factor loading matrix and its transpose. The genetic and environmental correlations among the three scales were also derived from the A, C, and E variances and covariances.

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The raw data option in Mx (Neale et al., 2003) was used to conduct model-fitting analyses. Before the data were applied to the full trivariate Cholesky model, a baseline model was constructed. In the baseline model, variances of MZ and DZ twins were allowed to differ, while variances of the first and the second twins were set to be equal. This model can serve as a baseline model because in the full trivariate Cholesky model, variances of MZ and DZ twins as well as those of the first and the second twins within each zygosity group were constrained to be equal. First, to determine whether the full trivariate Cholesky model is acceptable, the fit of the baseline model was compared to that of the full trivariate Cholesky model. Next, to select the best-fitting, most parsimonious model, submodels of the full trivariate Cholesky model were constructed and the fits of these submodels were compared with the fit of the full model using the criteria of Akaike information criterion (AIC = χ^2 – 2df) and the likelihood-ratio chi-square test (LRT). As the difference in chi-square between the full and reduced model is distributed as chi-square, the LRT was used to judge the best-fitting model when competing models were nested. A significant increase in chi-square in the reduced model as compared to the full model would suggest that the reduced model fit the data less well than the full model. A nonsignificant change in chi-square would indicate that the reduction of the model parameter is acceptable. If competing models were not nested, the model that produced the lower AIC was considered a better and more parsimonious model.

Results

Correlational Analyses

Table 1 shows phenotypic correlations, and twin and cross-twin cross-trait correlations for MZ and DZ twins among Extraversion, Neuroticism, and MOCIT on the basis of the total sample (N = 1504). MOCIT was significantly and positively correlated with Neuroticism (r = .44), but only weakly and negatively related to Extraversion (r = –.10), suggesting that persons with high scores on MOCIT tend to be high in Neuroticism and somewhat low in Extraversion. Overall these patterns of interscale correlations were consistent with those found in the literature of the relationships between OCD and personality traits (Alonso et al., 2008; Fullana et al., 2004; LaSalle-Ricci et al., 2006; Rector et al., 2002; Samuels et al., 2000; Wu et al., 2006).

For all three traits, MZ twin correlations were consistently greater than DZ twin correlations, confirming significant genetic influences on Extraversion, Neuroticism, and MOCIT found in previous studies (Hur & Jeong, 2008; Hur, 2007). Three cross-twin cross-trait correlations were also higher in MZ than in DZ twins. However, the cross-twin cross-trait correlations were very small except for those between Neuroticism and MOCIT. Taken together, these results suggested that genetic and environmental overlaps may be significant between Neuroticism and MOCIT, but only modest between Extraversion and MOCIT.

Model-Fitting Analyses

Identification of the Best-Fitting Model

The difference in fit between the baseline model and the full trivariate Cholesky model was nonsignificant ($\Delta\chi^2_{21}$ = 11.22, $p > .95$), suggesting that moving from the baseline to the full trivariate Cholesky model was acceptable.

Table 2 provides the results of fitting submodels of the trivariate Cholesky model to the data. A significant change in chi-square occurred when all variances and covariances of the three additive genetic factors were removed from the full model (Model 1). In contrast, elimination of the three shared environmental Cholesky factors yielded no significant change in chi-square (Model 2). While dropping additive genetic covariance between Extraversion and Neuroticism produced a significant difference in chi-square (Model 3), the corresponding individual specific environmental covariance did not (Model 4). These results suggested that the phenotypic correlation between Neuroticism and Extraversion may be mediated by shared genetic rather than shared individual specific environmental experiences.

Eliminations of the covariances of additive genetic and individual specific environmental factors between Extraversion and MOCIT, respectively from Model 2 yielded no significant change in chi-square (Models 5 and 6). However, when both additive genetic and individual specific environmental covariances between

Table 1

Phenotypic Correlations and Twin and Cross-Twin Cross-Trait Twin Correlations for Neuroticism, Extraversion, and the Total Score of the Maudsley Obsessive Compulsive Inventory to the Twin Data

			MZ (524 pairs)			DZ twins (228 pairs)		
Phenotypic correlations			Extrav1	Neuro1	MOCIT1	Extrav1	Neuro1	MOCIT1
MOCIT-Neuro	.44**	Extrav2	.51**	–.10*	–.04	.26**	–.08	.08
MOCIT-Extrav	–.10*	Neuro2	–.15**	.38**	.23**	–.12	.18**	.14*
Neuro-Extrav	–.19**	MOCIT2	–.10*	.23**	.47**	–.08	.13*	.35**

Note: MZ = monozygotic twins; DZ = dizygotic twins. Elements on the diagonals represent MZ and DZ correlations; Elements in the off diagonals represent MZ and DZ cross-twin cross-trait correlations. Neu = Neuroticism; Extrav = Extraversion. '1' represents the first-born twins and '2' represents the second-born twins. * $p < .05$, ** $p < .01$.

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Table 2

The results of fitting submodels of the trivariate Cholesky model to the twin data for Extraversion, Neuroticism, and the Total Score of the Maudsley Obsessive Compulsive Inventory (MOCIT)

		Difference in Fit from Full Model			
Model	Description	ΔX^2	Δdf	*p*	ΔAIC
1	Drop all VAR_a & COV_a	30.6	6	0	18.6
2	Drop all VAR_c & COV_c	5.3	6	0.51	–6.7
3	Same as Model 2, but drop COV_a between E & N	23.3	7	0	9.3
4	Same as Model 2, but drop COV_e between E & N	13.4	7	0.06	–0.6
5	Same as Model 2, but drop COV_a between E & M	9.1	7	0.24	–4.9
6	Same as Model 2, but drop COV_e between E & M	9.2	7	0.24	–4.8
7	Same as Model 2, but drop COV_a and COV_e between E & M	140.9	8	0	124.9
8	Same as Model 2, but drop COV_a between N & M	50.6	7	0	36.6
9	Same as Model 2, but drop COV_a between N & M	100.6	7	0	86.6
10	Same as Model 2, but drop COV_e between E & N and COV_a between E & M	19.6	8	0.01	3.6
11	**Same as Model 2, but drop COV_e between E & N and between E & M**	**14.3**	**8**	**0.08**	**–1.7**

Note: E = Extraversion, N = Neuroticism, M = The total score of the Maudsley Obsessive Compulsive Inventory; COV_a = additive genetic covariance, COV_c = shared environmental covariance, COV_e = individual specific environmental covariance;
VAR_a = additive genetic variance, VAR_a = shared environmental variance.

Extraversion and MOCIT were removed from Model 2 simultaneously, the change in chi-square was significant (Model 7). These results suggested that the present sample did not have a sufficient statistical power to distinguish between additive genetic and individual specific environmental covariance between Extraversion and MOCIT. Next, additive genetic and individual specific environmental covariances between Neuroticism and MOCIT were respectively removed from Model 2 (Models 8 & 9), both of which yielded significant changes in chi-square. These results suggested that both additive genetic and individual specific factors were important for the relationship between Neuroticism and MOCIT.

In addition to the individual specific environmental covariance between Extraversion and Neuroticism, additive genetic covariance between Extraversion and MOCIT was removed from Model 2 (Model 10). This procedure resulted in a significant change in chi-square. Finally, in Model 11, individual specific environmental covariances between Extraversion and Neuroticism and between Extraversion and MOCIT were removed from Model 2. The change in chi-square was not significant in Model 11. When AIC was compared between Models 10 and 11, it was lower in Model 11 than in Model 10, confirming that Model 11 was the best-fitting model. Model 11 showed that common genetic factors were important for the covariations among Extraversion, Neuroticism and MOCIT and that common individual specific environmental factors were significant only for the relationship between Neuroticism and MOCIT.

Estimates in the Best-Fitting Model

Figure 1 shows standardized genetic and environmental path coefficients and their 95% confidence intervals in Model 11.

Heritability and individual specific environmental factors were, respectively, 52% and 48% for Extraversion, 38% and 62% for Neuroticism, and 47% and 53% for MOCIT. The additive genetic correlations in the best-fitting model were .51 between Neuroticism and MOCIT and –.17 between Extraversion and MOCIT, suggesting that additive genetic factors that lead to high neuroticism and low extraversion overlap with those genetic factors influencing high OC symptoms. Additive genetic correlation between Extraversion and Neuroticism was also significant (r = –.39). Additionally, Figure 1 showed that the phenotypic relationships between Extraversion and MOCIT and between Extraversion and Neuroticism were entirely mediated by common additive genetic factors. For the phenotypic relationship between Neuroticism and MOCIT, however, the individual specific environmental correlation was also significant (r = .39).

Discussion

A growing literature suggests that personality traits may be endophenotype markers for psychiatric illnesses. Endophenotypes are heritable, quantitative traits hypothesized to closely represent genetic risk for complex polygenic mental disorders (Gottesman & Gould, 2003). The present findings suggest that high neuroticism and low extraversion may provide genetic risk factors for OC symptoms, representing the first evidence for personality endophenotypes of OC symptoms.

As high neuroticism and low extraversion have been shown to be genetically related to many anxiety spectrum phenotypes with little specificity, this personality profile is likely to be an index of general genetic vulnerabilities to various anxiety disorders rather than specific genetic risk factors influencing the development of a particular expression or the severity of OC symptoms.

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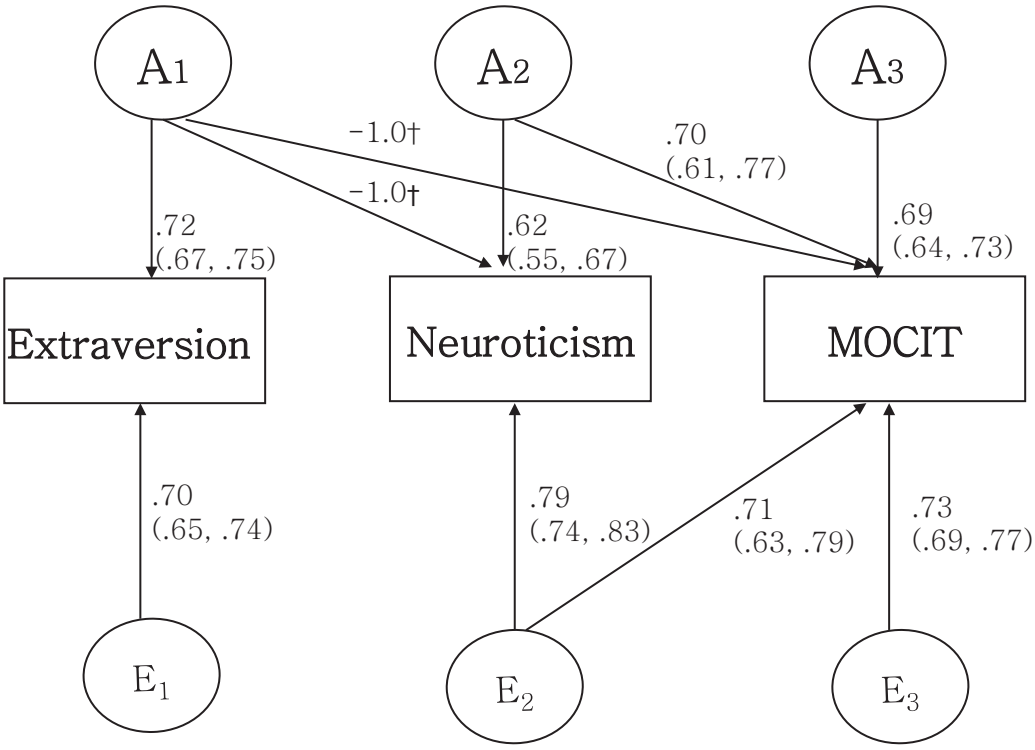

Figure 1

Standardized additive genetic (A_1, A_2, & A_3) and individual specific environmental (E_1, E_2, & E_3) path coefficients in the best-fitting trivariate Cholesky model for Extraversion, Neuroticism, and the total score of the Maudsley Obsessive Compulsive Inventory (MOCIT). Path coefficients can be squared to obtain proportions of variance due to each factor.

Note: † = 95% CI incalculable.

Neuroticism in the EPS represents the tendency to experience negative emotions such as anxiety, anger, feelings of guilt, and worry, whereas Extraversion is characterized by high levels of sociability and preference for large groups and gatherings. One could argue that persons with OCD tend to be low in sociability, overaroused, and unable to relax because they usually realize that their obsessive-compulsive behaviors are irrational and inadequate. However, longitudinal studies have shown that these personality characteristics showed up long before the symptoms appeared (Caspi et al., 1995), indicating that the neurotic state and avoidance of social gatherings often found among individuals with OCD may not necessarily be the consequence of the OC symptoms.

The results of the present multivariate twin analyses suggest that pleiotrophic effects of genes may cause the relationships among OC symptoms, neuroticism, and extraversion. Several recent studies have found evidence of associations of 5–HTTLPR, monoamine oxidase A (MAOA) gene, and Val158Met and rs737865 in the COMT gene with high neuroticism and/or low extraversion (Hettema et al., 2008; Lesch et al., 1996; Stein et al., 2005; Tochigi et al., 2006). In support of the present findings, some of these polymorphisms have been reported to be involved in symptoms of OC and other anxiety disorders (Poorley et al., 2007; Stein et al., 2005). However, as the results from replication studies of these associations have been inconsistent (Wray et al., 2008), further linkage and association studies are warranted to clarify a better understanding of the genetic overlap among OC symptoms, neuroticism, and extraversion.

The present study also demonstrates that approximately half of the phenotypic relationship between neuroticism and OC symptoms was explained by common individual specific environmental influences. That is, environmental experience factors that lead to high neuroticism overlap with those environmental factors important for high OC symptoms. It is well documented that adverse life experiences such as exposures to childhood abuse and neglect or parental separation or loss precipitate the onset of anxiety disorders (Kessler et al., 1997; Molnar et al., 2001). The significant common individual specific environmental correlation between neuroticism and OC symptoms found in the present study suggest that negative life experiences that influence OC symptoms can also contribute to the development of neuroticism. In line with this finding, Gothelf et al. (2004) have shown that as compared to healthy controls, children and adolescents with OCD not only scored higher in harm avoidance but also had significantly more negative life events. Recently, Middeldorp et al. (2008) found in a

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longitudinal twin study that the relationship between neuroticism and life events could be explained by reciprocal causation such that neuroticism increased exposures to life events, while the experience of life events also increased the level of neuroticism.

Notable also is that individual specific environmental correlations between extraversion and OC symptoms were negligible, indicating that the life experiences that increase vulnerability to OC symptoms have little overlap with those important for high extraversion. These results were consistent with the Middeldorp et al. (2008) study which also showed that extraversion was not related to negative life events.

There are several limitations in the present study. First, as the statistical power was limited due to relatively small samples, especially the DZ twin sample, the present study was not able to resolve several important research issues such as sex differences or age differences in the relationship between personality traits and OC symptoms. Previously, genetic factors in OC symptoms were shown to be larger in males than in females among South Koreans (Hur & Jeong, 2008). Therefore, it would be of interest in future study to explore sex differences in genetic and environmental covariances between OC symptom, extraversion, and neuroticism in a larger sample. The age range of the twins in the present study was large, including both adolescents and young adults. Although personality characteristics exhibit stability across adolescence and young adulthood (Roberts & DelVecchio, 2000), changes in gene actions may occur during this period, especially in puberty. Future research, therefore, should increase the sample size and examine the covariations of OC symptoms and personality traits separately in adolescents and young adults.

Second, the pattern of MZ and DZ twin correlations for MOCIT in the present study showed a hint of shared environmental factors, although shared environmental factors did not attain a statistical significance perhaps due to a lack of statistical power. However, an absence of shared environmental factors in personality traits during adolescence and young adulthood has been well replicated in South Korean samples (Hur, 2006; Hur, 2007) as well as in many Western twin studies (Loehlin, 1992). Thus, it is unlikely that shared environmental factors play a significant role in the covariations between personality traits and OC symptoms.

Third, in the present study, as personality traits and OC symptoms were measured concurrently using the self-report inventory, some of the individual specific correlations between OC symptoms and neuroticism may include correlated measurement error. Because this measurement error can reduce twin correlations also, the genetic correlations between neuroticism and OC symptoms may have been underestimated in the present study. Finally, subjects in the present study were a volunteer sample of South Korean adolescent and young adult twins. The participation rate in this study was modest (approximately 32%). Thus, these results may not generalize to the South Korean population as a whole or to other ethnic groups.

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