

Seoul Twin Family Study: Design, Sampling, Assessments, and Future Directions

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The Seoul Twin Family Study seeks to investigate genetic and environmental influences on the development of cognitive abilities and other psychological traits among children and adolescents in Seoul, South Korea. In November, 2001 with the assistance of the Seoul Metropolitan Office of Education, we began to solicit all private and public schools in Seoul to obtain names, addresses, and telephone numbers of the twins enrolled in schools in Seoul. The vast majority of the recruited twins were between 6 and 18 years old. The recruited twins and their non-twin siblings and parents will undergo comprehensive assessment of cognitive abilities, interests, daily activities, personality, and familial and non-familial environments. We plan to reassess the twins and their families every two years as the twins progress through major changes that characterize childhood, adolescence, and adulthood. In addition, medical records of the twins during the prenatal period will be examined to determine the effects of intrauterine environment on individual differences in cognitive abilities and other psychological traits. We also plan to undertake molecular genetic studies to identify genes involved in specific cognitive abilities.

Study Design and Major Research Goals

The Seoul Twin Family Study (STFS), which was initiated in 2001, is a longitudinal, population-based twin family study in Seoul, South Korea. The primary goal of the STFS is to understand the developmental process of cognitive abilities in children and adolescents in Seoul, South Korea from a behavioral genetic perspective. A large sample of children and adolescent twins (age: 6–18 years) and their non-twin siblings and parents, ascertained from all private and public schools in Seoul, will undergo comprehensive assessments of cognitive abilities, interests, daily activities, personality, and familial and non-familial environments. The sample will be reassessed every two years as the twins progress through major changes that characterize childhood, adolescence, and adulthood.

To date, more behavioral genetic studies have been conducted for cognitive abilities than for any other psychological trait (Plomin et al., 2000). These studies have convincingly demonstrated substantial genetic and moderate amount of shared environmental influences on individual differences in cognitive abilities. Most behavioral genetic studies of cognitive abilities, however, have been

undertaken in the United States and European countries, which limits generalizability of the findings across different human populations. Given that gene frequencies, mating habits, social values, and environmental characteristics vary in different cultures, crosscultural comparisons of heritability and environmentality are clearly needed for understanding the nature of genetic and environmental influences on cognitive development. The STFS is one of only a few groups in Asia who have been able to establish a large population-based twin registry.

Recent longitudinal behavioral genetic studies of cognitive abilities have shown that genetic influence increases, whereas shared environmental influence diminishes with age in European populations (e.g., Cardon & Fulker, 1993). However, there is little known about the developmental process of “how” genetic factors of cognitive abilities are amplified over time. As developmental models for the joint influence of genes and the environment, Scarr and McCartney (1983) proposed three kinds of genotype-environment correlation: passive, reactive, and active. Passive genotype-environment correlation arises when parents provide their children with genes and environment correlated with their genetic predisposition. For example, intellectually gifted parents will provide their children with intellectually stimulating environments as well as intellectual heritage. With the use of twin-family data the contribution of passive genotype-environment correlation to the variance of cognitive abilities can be estimated. Reactive genotype-environment correlation refers to experiences of the child that derive from reactions of other people to the child’s genetic propensities. Active genotype-environment correlation describes the situation where children actively select or create their own environments that are correlated with their genetic propensities. For example, intellectually gifted children actively select and engage in intellectual activities, and construct experiences and environments that further raise their intellectual abilities.

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In Western societies, because most children are relatively free to pursue what they are interested in and talented at, the active kind of genotype-environment correlation is likely to play a crucial role in children's development, whereas the passive kind of genotype-environment correlation is minimal. In South Korean society, however, much of the child's environment is constrained by their parents until late adolescence. The passive genotype-environment correlation, therefore, is likely to be substantial, whereas the active genotype-environment correlation is modest in South Korean society. These comparisons of processes underlying genotype-environment correlation in different cultures will illustrate how the social environment can mediate genetic influences on cognitive abilities.

Although active genotype-environment correlation for cognitive abilities has been suggested to be an important developmental mechanism, it has been difficult to detect empirically. In order to fully evaluate the processes of active genotype-environment correlation in the cognitive development, the STFS includes comprehensive assessments of daily activities, interests, and personality that may affect the development of cognitive abilities as well as cognitive abilities themselves in twins and their non-twin siblings and parents in the context of a longitudinal design. These assessments will allow us to explore the role of active genotype-environment correlation in the process of cognitive development in children and adolescents in South Korea, and compare the results with those found in Western societies.

Critics of the twin method have argued that because the influence of intrauterine environments has not been incorporated in the behavior genetic models, estimates of genetic influence might be falsely elevated (Devlin et al., 1997). Recently, some authors (e.g., Jacobs et al., 2001) have indeed demonstrated the importance of prenatal effects on cognitive abilities. With the hospital records of the twin participants during the prenatal period, the STFS attempts to investigate the influence of prenatal variables on postnatal phenotypes and examine to what extent the prenatal environments explain the variance of cognitive abilities and other psychological traits.

The finding that genetic factors are responsible for the major source of variation for cognitive abilities has led to several systematic attempts, with limited success, to identify specific genes involved in cognitive abilities. As for most complex behaviors, many genes are likely to affect cognitive abilities. While research efforts of the molecular genetics of cognitive abilities to date have been directed toward finding genes for the general factor of cognitive abilities, recently it has been proposed that different cognitive processes are independently affected by a different set of genes (Mackintosh, 1998). This notion implies that specific cognitive abilities may be more useful than the general cognitive ability to identify genes for the cognitive abilities. With the participants of the STFS, we plan to study specific cognitive abilities rather than the general cognitive ability to locate genes for cognitive abilities. Among the specific cognitive abilities, we are most interested in spatial abilities.

In sum, the STFS aims to resolve significant issues in the behavior genetic literature of cognitive abilities as follows:

1. Are the estimates of genetic and environmental influences on cognitive abilities and related psychological traits in children and adolescents in Seoul comparable to those found in Western societies?
2. Do the estimates of genetic and environmental variance components in cognitive abilities and associated traits in children of Seoul increase, decrease, or remain stable with age?
3. What are the mechanisms of cognitive development in children and adolescents in Seoul? Specifically, given the social influence in South Korea, to what extent do the passive and active genotype-environment correlations explain individual differences in cognitive abilities in children and adolescents in Seoul?
4. Are prenatal variables (e.g., chorion type, placentation, etc.) significantly related to cognitive abilities in children and adolescents? If so, to what extent do the prenatal environments explain individual differences in cognitive abilities?
5. What are the genes involved in specific cognitive abilities?

Recruitment and Sampling

The target population of the STFS is the twins enrolled in all of the private and public schools in Seoul as of year 2001. In November 2001, with the assistance of the Seoul Metropolitan Office of Education, we sent solicitation letters to all private and public elementary and junior and senior high schools in Seoul to obtain names, phone numbers, mailing addresses, and email addresses of all twins enrolled in schools in Seoul. The number of private and public elementary and junior and senior high schools in Seoul as of year 2001 is 1168, comprising approximately 1,540,000 students (Statistical Yearbook of Seoul Education, 2001).¹ By the end of January, 2002, 996 of the 1168 schools (about 85.3%) provided us with information on twins enrolled in their schools, yielding a sample of 4615 twin pairs.

Table 1 shows the total number of elementary and junior and senior high schools in Seoul, number of schools who returned letters to us, and number of twins ascertained as of January 2002. As Table 1 indicates, the return rate was lower for higher grades. This reflects that high schools have a much busier calendar than elementary schools, especially as the school year nears its end. We are currently sending a second prompt to the schools that have not responded to us. Our goal is to contact all the schools that have not responded and obtain the information about twins by the end of February 2002. Given that elementary school is compulsory and that the school enrollment rates for the junior and senior high schools in Seoul are over 99.5% (Statistical Yearbook of Seoul Education, 2001), we feel confident that our twin registry will include almost all the twins between the ages of 6 and 18 years residing in Seoul when the scheduled recruitment procedure is successfully completed.

Table 1

Number and Percentage of the Responding Schools and Twins Ascertained as of January 2002 in the Seoul Twin Family Study

School	Grade	No. of schools responded/ total No. of schools in Seoul*	% of schools responded	No. of twin pairs ascertained
Elementary	1–6	476/536	88.8%	2945
Junior High	7–9	293/354	82.8%	1014
Senior High	10–12	227/278	81.7%	656
Total		996/1168	85.3%	4615

Note: * Figures for the total number of schools are from the Statistical Yearbook of Seoul Education (2001).

While making efforts to contact schools to acquire information on twins, we started our first mail and email surveys to the located twins in January, 2002. Our first survey included an introductory letter describing the project, a zygosity questionnaire that included questions concerning physical similarities of the twins and the frequency with which the twins were confused by family members and others, demographic questions on twins and their family members, and other survey questions such as whether they would like to take cognitive ability tests, whether they would like to volunteer a small blood sample to confirm zygosity, and so forth. For elementary school twins, we asked their parents to complete the zygosity and the demographic questionnaires, and other survey questions. For junior and senior high school twins, we asked the twins, themselves, to fill out these questionnaires.

Our first survey also included Piers-Harris Children's Self Concept Scale (Piers, 1976) for all elementary school twins, and Personality Rating for the twins older than the third grade and all parents of the twins. As a token of our appreciation, we offered a telephone card or a lottery ticket to the twin families who completed and returned the questionnaires to us. We also assured the twins and their parents that we would provide feedback on their responses to the questionnaires, which served as an important incentive for them.

We noted that the majority of the junior and senior high school twins had emails. To those junior and high school twins who had email accounts we sent our surveys by email; to those who did not have email accounts or whose email addresses were incomplete, we sent them by mail with a return envelope. To the elementary school twins, we sent our surveys by mail with a return envelope regardless of whether they had emails or not. After we sent the mail survey to the elementary school twins, in order to prompt their responses, we emailed a notice of our mail survey to those elementary school twins who had email accounts.

To maintain twins' interest in our project, we are currently running a web site (<http://www.ktrc.org>) for the twins and parents of the twins where we provide information on the twinning rate statistics, tips for raising twins, and other twin issues. We also encourage twins and parents of the twins to exchange their experiences and helpful information on our web site. We have noticed that the number of twins and parents of the twins who visit our web site has been steadily increasing.

Twins and their parents who participate in the STFS will also be contacted periodically with newsletters. This regular contact will provide project updates to all participants and provide a means of locating twin families who have moved.

Assessments

Our core assessment battery was designed to provide comprehensive measures of psychological traits and familial and non-familial environments that would contribute to the resolution of the issues in understanding development of cognitive abilities. The major domains of psychological traits to be assessed in the STFS are general and specific cognitive abilities, information processing abilities, daily activities, interests, and personality. Additionally, intellectual, physical, and emotional aspects of familial and non-familial environments will be assessed. In the future we hope to include psychophysiological markers of cognitive abilities. In choosing specific measures in each psychological domain we strove to achieve four goals. First, they have psychometric evaluations. Second, they have been used in the kinship studies conducted in Western societies so that the data in the STFS can be compared with the results of the Western data directly or indirectly. Third, for almost every psychological construct more than one test was included in an attempt to control measurement errors. Fourth, care was taken to insure that the assessments are developmentally appropriate, especially for the young twins.

Table 2 shows a summary of the planned core assessments in the STFS.

Future Directions

The STFS is one of the first population-based, longitudinal twin family studies in Asia. The STFS represents a unique research opportunity to identify genes for specific cognitive abilities and test for the roles of active and passive genotype-environment correlations in cognitive development in children and adolescents in Seoul. The STFS will also examine the effect of prenatal environment on cognitive development, which is a relatively unexplored realm in behavioral genetic literature of cognitive abilities.

The design of the STFS has much strength. First, it includes non-twin siblings. The assessments of non-twin siblings will enable us to examine whether twins differ statistically from singletons and whether fraternal twins are more similar than non-twin siblings. Second, it includes

Table 2

A Summary of the Core Assessments in the Seoul Twin Family Study*

Measure	Brief Description
Cognitive abilities	
Wechsler Intelligence Scale for Children — Revised (WISC-R) and Wechsler Adult Intelligence Scale — Revised (WAIS-R)	Standardized measures of intelligence for children (WISC-R) and adults (WAIS-R)
Card-Rotations	A measure of the mental rotation ability
Mental Rotations	A measure of the mental rotation ability
Paper Form Board	A measure of the spatial visualization ability
Hidden Patterns	A measure of the spatial visualization ability
Water Level	A measure of the spatial perception ability
Rod & Frame	A measure of the spatial perception ability
Identical Pictures	A measure of perceptual speed and accuracy
Perceptual Speed	A measure of perceptual speed and accuracy
Immediate Visual Memory	A measure of visual memory
Delayed Visual Memory	A measure of visual memory
Pedigrees	A measure of mental abilities, a good correlate of 'g' factor
Raven Progressive Matrices	A nonverbal measure of intelligence
Information Processing Abilities	
<i>Activities</i>	
Daily Activities	A measure of daily activities in various areas (e.g., reading, entertainment, physical exercise, etc.)
Spatial Experience Questionnaire	A measure of the amount of experience requiring spatial visualization
<i>Interests</i>	
Leisure-Time Interests	A self-report of interests and preferences for various leisure activities (e.g., sports, reading, travel, etc.)
Inventory of Occupational Interests	A measure of interests in various occupations
Strong Interest Inventory	A measure of interests and preferences for various occupations, school subjects, and activities
Personality	
Personality-Rating	A self-rating inventory of 34 Likert-type personality items.
California Psychological Inventory	A self-report inventory of 480 personality items with yes/no responses.
Family Environments	
Family Environment Scale	A measure of family atmosphere (mainly assesses family nurturance and control)
Parental Environment Questionnaire	A measure of the quality of the twin's relationship with each parent
Opinions on Child Rearing	A measure of attitudes toward various parenting practices and expectations about children's behavior
Environmental Assets	A measure of family material possessions
Prenatal environments	
Medical exam records during the twin pregnancy	Comprehensive medical exams records during the twin pregnancy that include ultrasound results, chorion types, placentation, gestational age, birth weight, and so forth.
Physical development	
Height	Self-report of height
Weight	Self-report of weight
Birth weight	Self-report of birth weight
Tanner	A measure of puberty that assesses physical development in secondary sexual characteristics
Other assessments	
Zygosity	An eight-item assessment to determine the twin's zygosity
Demographic Information Questionnaire	Provides demographic data of the twins and their families
Handedness Questionnaire	A self-report of handedness
Piers-Harris Children's Self-Concept Scale	An assessment of perceptions of the self in various areas
Opinions and Attitudes	A rating of opinions on how one would react in various situations (e.g., cheating in school) and feelings about various statements (e.g., "My friends come first with me.")
Inventory of Talent	A measure of self-perception of ability
Religious Background Survey	An assessment of current and past religious affiliations and activities
Friends	An assessment of peer characteristics

Note: * Items of the inventories originally developed in English were either directly translated into Korean or adapted to Koreans. Further details of the inventories are available from the author upon request.

parents of the twins, which will allow us to determine how assortive mating influences genetic and environmental variance estimates as well as the degree of assortive mating for cognitive abilities and other psychological traits. The analysis of assortive mating is critical in studying cognitive abilities among South Koreans because South Koreans have shown a very high degree of assortive mating for cognitive abilities (Johnson et al., 1976). Third, our inclusion of the opposite sex twin pairs will allow us to examine gender difference in the magnitude of genetic and environmental effects and determine whether or not the same set of genes or shared environmental experiences influence cognitive abilities and other psychological traits. Finally, a wide age range (6–18 years old) of the twin participants in the STFS will permit cross-sectional analyses in children and adolescents as well as longitudinal analyses of developmental continuity and change in cognitive abilities and other psychological traits.

Seoul is the largest city in South Korea with a population of approximately 10 million (about 21% of the whole population in South Korea). The junior and senior high school enrollment rates in Seoul are similar to those in the whole country. The socioeconomic status of families living in Seoul, however, is likely to be higher than that of families in the rest of the country. For this reason, the twin participants in the STFS may not represent all the children and adolescents in South Korea, and caution needs to be taken so that results are not over-generalized. In the future we plan to extend our twin family study to other areas in South Korea. We are especially interested in twin children and adolescents in extremely socially disadvantaged environments in South Korea. Extending our study to the twins and their families living in extreme deprivation will provide a valuable opportunity to evaluate the impact of environmental deficit on children's cognitive development.

Another major limitation of the STFS is that because the vast majority of the participants in the STFS are 6–18 years of age, environmental factors and some precursor activities, interests, and personality characteristics that may be critical for the development of cognitive abilities during infancy and early childhood cannot be identified from the STFS data. In the future we hope to undertake an infant twin project where we gather data from infant twins born in major hospitals in Seoul and follow them longitudinally. The infant twin project will allow us to chart the emergence of interests and activities and determine how these

interests and activities and environmental factors are related to the developmental outcome of cognitive abilities.

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Footnote

- 1 Special schools for the children and adolescents with mental and physical disabilities were excluded.

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