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# Registry of Adolescent and Young Adult Twins in the Tokyo Area

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Chizuru Shikishima,<sup>1</sup> Juko Ando,<sup>1</sup> Yutaka Ono,<sup>2</sup> Tatsushi Toda,<sup>3</sup> and Kimio Yoshimura<sup>4</sup>

<sup>1</sup> Department of Human Sciences, Faculty of Letters, Keio University, Japan

<sup>2</sup> Health Center, Keio University, Japan

<sup>3</sup> Department of Medical Genetics, Osaka University Graduate School of Medicine, Japan

<sup>4</sup> Department of Health Policy and Management, School of Medicine, Keio University, Japan

Since established in 1998, the Keio Twin Project (KTP) has been dedicated to investigating genetic and environmental sources contributing to human psychological traits in adolescence and young adulthood. A population-based twin registry was constructed by the KTP through the use of official residential records in the Tokyo area, and to date requests to participate in our research have generated 1040 pairs of twins and triplets of age 14 to 30, forming one of the largest twin registries in Asia. Our comprehensive datasets, obtained through questionnaires, performance tests, and physical measurements, cover a wide range of human traits: personality, psychiatry, mental health, sociality, cognition, and physical index. Demographic variables and environment of upbringing are also sought by twins and by some parents. This extensive information allows us to clarify the genetic and environmental overlap across multiple traits as well as specificities unique to single traits. Adding an evolutionary psychology perspective to the behavior genetics framework is currently being attempted in order to develop a grand theory of human genetics.

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## Research Purpose

The Keio Twin Project (KTP) was established in 1998, funded by the Grant-In-Aid Science Research of the Ministry of Education, Culture, Sports, Science and Technology and the Human Frontier Science Program to conduct behavioral genetic studies in a classic twin design for various kinds of human psychological traits in adolescence and young adulthood. This project mainly targets the source of normal variations in human behavioral characteristics in a general population. The variables contain comprehensive human behavioral and psychological traits: personality, psychiatry, mental health, sociality, cognition, physical traits, and so on. Recently, a new perspective involving evolutionary psychological research questions has been added to our behavioral genetic studies, which attempts to integrate genetics as applied to the adapta-

tion of the human species, macrogenetics, to genetics focusing on individual differences in behavior, microgenetics.

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## Twin Recruitment

The construction of a twin registry is a prerequisite for a twin study. Since no information of the national population based on birth records is publicly accessible in electronic format in Japan, gathering names, by hand, of family members who live together and have the same dates of birth from official residential records available at city halls is the only way to construct a population-based twin registry. Thus, from 1998 to 2002, a registry consisting of approximately 6000 pairs of 14- to 30-year-old native Japanese twins or triplets living in Tokyo and neighboring cities was constructed by the KTP. Letters soliciting participation in our project were mailed out according to the list, and approximately 1000 pairs agreed to participate in the research. This lower sampling rate compared to those of Western studies may partially reflect intrinsic psychological differences between Japanese and Western peoples, with the Japanese being more reluctant to discuss their psychological states with scientific researchers or other virtual strangers, and being reticent about taking part in research activities generally. The letter requesting participation contained written explanations to inform the participants of the research purpose of the project, the research items, protection of their privacy, and their right to cancel their participation at any time. An informed consent agreement document was completed by all the participants, as well as by their parents for those under age 20.

With respect to data gathering, as an entry phase, a questionnaire covering comprehensive psychological traits was sent by mail and participants were required to complete it at home and return it. Follow-up

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Received 10 September, 2006; accepted 19 September, 2006.

Address for correspondence: Chizuru Shikishima, 1-40-30 Narita-higashi, Suginami-ku, Tokyo 166-0015, Japan. E-mail: kana-s@sa2.so-net.ne.jp

questionnaires are now sent once a year. In addition, cognitive ability tests and physical measurements are conducted at Keio University almost every year. Prior to every survey, a written explanation concerning the study is provided and informed consent is obtained. The consent of the Institutional Review Board at the Faculty of Letters of Keio University is also secured to cover every study carried out in this project.

Since 2002, we have asked some 300 pairs of twins registered with the KTP for their parents' participation in our research. To date, 196 mothers and 173 fathers have agreed to participate, and questionnaires seeking demographic variables, family environment, parenting styles, and mental health have been completed.

### Zygoty Determination

The zygoty of each same-sex twin pair registered was initially diagnosed by a 3-item questionnaire based on physical resemblance developed by Ooki and his co-researchers (1990). This questionnaire is basically a translated version of Torgersen's questionnaire for zygoty diagnosis (Torgersen, 1979). The items are: 'Were you and your co-twin as alike as two peas in a pod?', 'Were you and your co-twin mixed up as children?' and 'If so, by whom were you mixed up?'. According to the degree of similarity, the first question was scored from 1 (*as alike as two peas in a pod*) to 3 (*quite different*), the second question from 1 (*yes, very often*) to 3 (*never*), and the third from 1 (*parents*) to 4 (*nobody*). The twins were required to answer these questions separately; therefore, the total score for siblings could range from 6 to 20. In accordance with the cut-off point established for this scale, those with a sibling total score of 6 to 13 were diagnosed as monozygoty (MZ) twins, and 14 to 20 as dizygoty (DZ) twins. The number of pairs who answered this questionnaire was 847.

Among them, gene polymorphisms at a maximum of 10 highly informative loci were examined by 288 pairs through blood or buccal smears. If all markers are concordant within a certain twin pair, the probability of being MZ calculated using Bayes theorem is more than .99. It was confirmed that 93% of these DNA-based diagnoses were in agreement with initial questionnaire-based diagnoses.

For those not providing blood or buccal smears, whose zygoty scores on the questionnaire were on the borderline, and for whom photographs were available, an assessment of similarity in photographs by three twin researchers blind to information about this sample was made. More than four different color photographs of pairs taken at Keio University were assessed from the score of 1 (*extremely alike*) to 4 (*not alike at all*) according to the level of physical similarity. The total score by the three raters should range from 3 to 12, and eight pairs with a total score below 6 but marginally classified as DZ from the questionnaire were adjusted to be MZ, while a pair with a

score of 11 but marginally classified as MZ from the questionnaire were adjusted to be DZ.

As a result, the effective number of twin pairs was broken down as follows: 673 (459 female and 214 male) pairs of MZ twins and 325 (128 female, 58 male, and 139 male-female) pairs of DZ twins. The number of pairs whose zygoty was unknown, that is, from whom no effective zygoty information based on questionnaire or DNA was available, was 42.

## Datasets and Major Findings

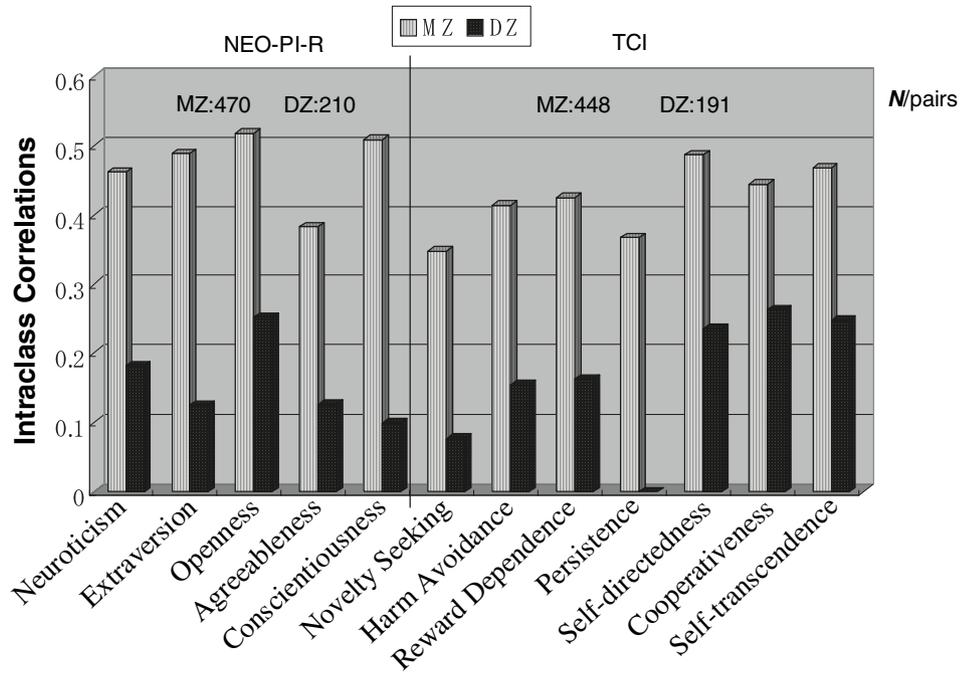
### Personality, Psychiatry, and Sociality

One of the major focuses of our research has been identifying the genetic and environmental structures which affect personality. Figure 1 shows the intraclass correlations for MZ and DZ with respect to five personality domains as measured by the full scale of NEO Personality Inventory-Revised (NEO-PI-R) and seven personality factors as measured by the full scale of Cloninger's Temperament and Character Inventory (TCI). Each dimension suggests substantial genetic effects, and heritability estimates of 40 to 50% are equivalent to Western findings. A recent study compared phenotypic, genetic, and environmental factor structure of the NEO-PI-R among Canadian, German, and our Japanese KTP samples, and demonstrated a highly congruent genetic and environmental structure for personality across these diverse cultures, implying the universality of the human personality structure (Yamagata et al., 2006). The comprehensive genetic and environmental structures for all seven dimensions of the TCI were investigated, bringing about a new framework for Cloninger's sociobiological personality model (Ando et al., 2002, 2004). Multivariate genetic analyses revealed a possibility of constructing more genetically homogeneous scales than those provided by the original theory.

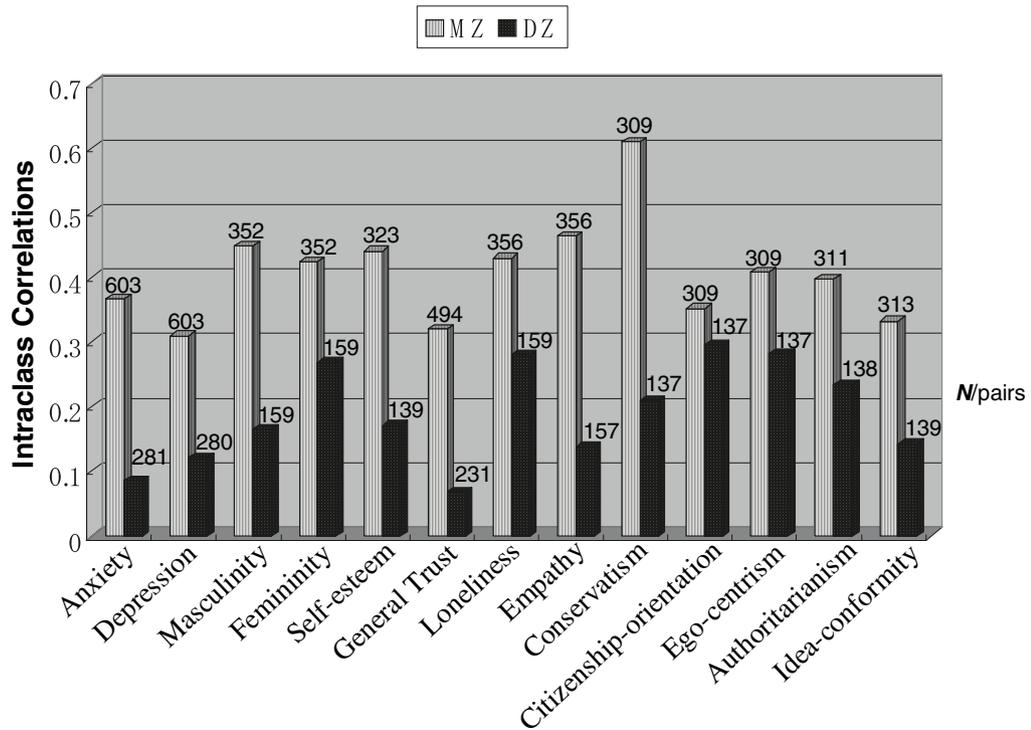
The association between personality traits and mental health has also been of great interest to us. The etiology of such psychiatric variables as depression, anxiety, substance abuse, autism, eating disorders, and gender identity disorders is currently being explored. So far, a multivariate genetic analysis has revealed that genetic factors contributing to three temperament dimensions entirely explain the genetic factor of depression, that is, there is no genetic factor that uniquely contributes to depression (Ono et al., 2002).

Genetic and environmental causes that affect the development of individual sociality have been widely sought. Intraclass correlations of some sample variables are in Figure 2. Substantial genetic components were observed for each variable, and an ongoing study suggested a high heritability estimate, 63% for conservatism. Shared environmental components were also implied, as for such attitudes as citizenship-orientation and ego-centrism.

The study, which examined genetic and environmental influences on stability and change in self-esteem during adolescence using a longitudinal behavioral



**Figure 1**  
Intraclass correlations for MZ and DZ as for personality variables.



**Figure 2**  
Intraclass correlations for MZ and DZ as for psychiatric and social psychological variables.

genetic design, has shown that stability in self-esteem across two time points was due to genetic and non-shared environmental effects, whereas change in self-esteem was explained by nonshared environmental influences (Kamakura et al., in press).

**Cognitive Abilities**

With respect to intelligence performance tests, four subtests of the WAIS have been conducted using an individual test method, and the full version of a Japanese standardized intelligence test (the Kyodai-Nx), and Vandenberg’s mental rotation test have been administered in a group fashion. The total IQ is calculated from the Kyodai-Nx, producing a heritability estimate of 75% with no shared environmental effect, which is comparable to the results reported in Western societies. Intraclass correlations for MZ and DZ as for some available cognitive variables are shown in Figure 3.

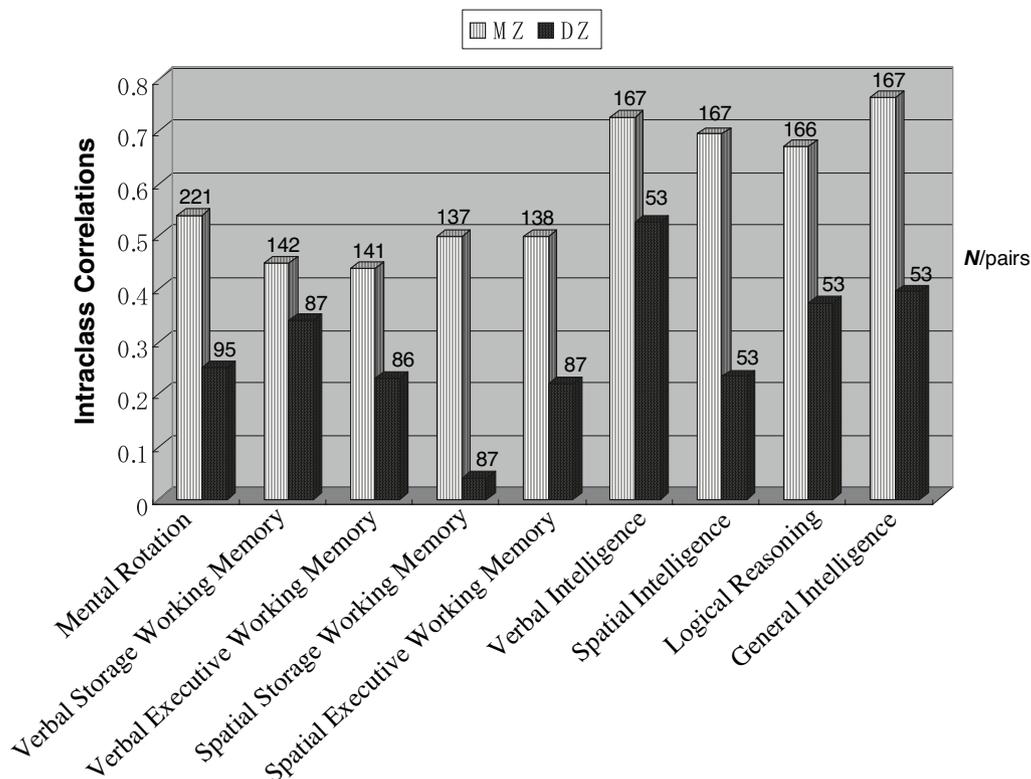
Figure 4 highlights 12 Kyodai-Nx subtest scores for a pair of MZ twins; the profile is extremely similar between the two members of this MZ pair. An ongoing study suggests a higher heritability for spatial intelligence than verbal intelligence, and this finding is more accurately illustrated by the data for two different processes of working memory function, executive and storage, and for two different modalities, verbal and spatial (Ando et al., 2001).

To clarify the characteristics of general intelligence in a more process-oriented way, we developed a well-structured logical reasoning test, the BAROCO, by means of traditional syllogistic tasks (Ando et al., 2006; Shikishima et al., 2005). A multivariate analysis of verbal IQ, spatial IQ, and scores obtained from 100 problems of syllogism-solving with a combination of different types and formats, produced a common latent factor, which is highly genetic. The hierarchical structure of cognitive abilities, as well as cognitive processing, supports the psychometric model of human intelligence.

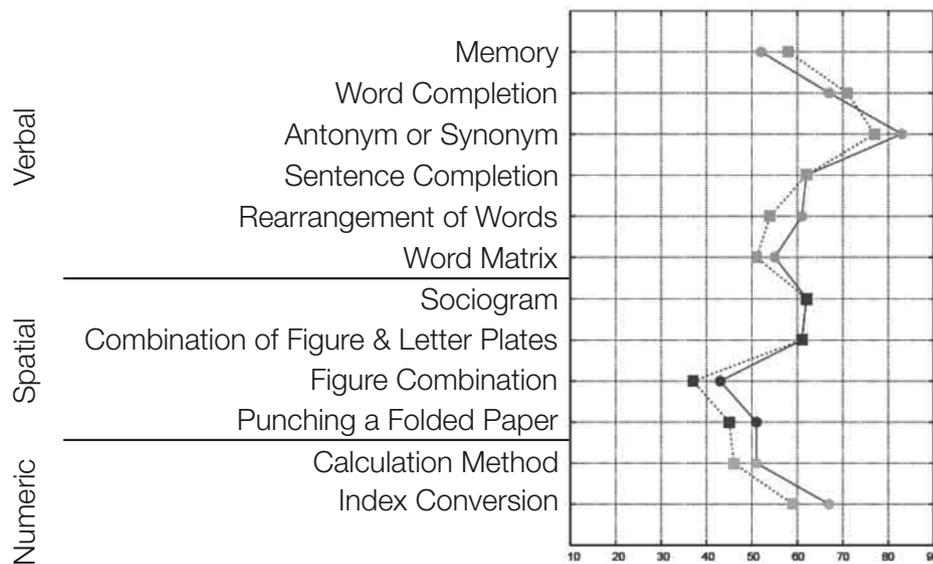
**Environment**

Environment of upbringing is measured from several angles. Retrospective parenting styles, family cohesion, and parent–offspring communication in childhood are assessed both by each twin and by parents. Univariate genetic analyses have revealed substantial genetic influences on these family features. ‘Nature of nurture’ found in Western families was observed in Japanese families as well.

Our focal research issue is to determine elements of experiences that moderate genetic and environmental effects, causing interactions between genes and environment or between environment and experiences. To resolve this research issue, we have been analyzing various environmental variables treating them as moderator variables. So far, it has been suggested that the



**Figure 3**  
Intraclass correlations for MZ and DZ as for cognitive variables.



**Figure 4**

Kyodai-Nx 12 subtest scores for one pair of MZ.

Note: Circular points belong to one twin and square points to the co-twin. Each individual score is connected by a line.

cohesion of family and parental warmth can increase the manifestation of shared environmental effects on social attitudes (Shikishima & Ando, 2004), and stressful life events can suppress the expression of genetic influences on depressive and anxious moods.

Specific experiences which could bring about non-shared environmental factors affecting behavior have also been explored by analyzing items of the Sibling Inventory of Differential Experience (SIDE).

### Future Plans

Behavioral genetic studies have rapidly changed their approach to include more biological and molecular genetic methods. Our project is now conducting a brain-imaging survey using NIRS (Near Infrared Spectroscopy or Optical Topography) and ERPs (Event-Related Potentials) to analyze endophenotypes of cognition. A molecular biological approach, such as epigenetic effects estimated by gene expression differences between discordant MZ twins, is also being attempted. Asian twin data are of great importance to the behavior genetics literature, which to date has been virtually dominated by Western findings. The KTP is one of the largest twin study projects in Asia. Our comprehensive datasets should play a critical role in understanding the genetic universality and specificities of human behavioral traits.

### Acknowledgments

We wish to thank the following co-researchers of the Keio Twin Project for their contribution to the study by working with and gathering the data from the study participants: T. Hasegawa, K. Hiraishi, N. Hirose, T. Kamakura, S. Kanba, N. Kijima, H. Maekawa,

K. Mochizuki, R. Nakajima, M. Okada, N. Onoda, Y. Osana, S. Sasaki, M. Sato, A. Senju, Y. Sugimoto, A. Suzuki, K. Suzuki, Y. Takahashi, M. Takayama, R. Takemura, and S. Yamagata.

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