

The Taipei Adolescent Twin/Sibling Family Study I: Behavioral Problems, Personality Features, and Neuropsychological Performance

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The present study aimed to investigate genetic and environmental influences on behavioral problems, personality features, and neuropsychological performance among adolescents in Taipei, Taiwan. Between 1996 and 1998, with the assistance of the Twin Association and junior high schools in Taipei City, we solicited a list of twins from 51 junior high schools in Taipei. Names, addresses, and telephone numbers of the twins enrolled in these schools were obtained. The vast majority of the recruited twins were between 12 and 16 years old. The recruited twins received assessments for behavioral problems, general and schizotypal personality, and cognitive functions. Their parents rated their children on behavioral/emotional problems and were assessed on their own general and specific personality. Same-sex sibling pairs (ages vary within 2 years) and their parents from three schools were also recruited to increase sample size for the group with a kinship coefficient of .50. Twins' zygosity was determined by a combination of DNA typing and physical similarity. The Mx program was used to estimate parameters for the full model and its reduced models. The recruitment, measurements, data managements, and published results are described in this article.

There have been an increasing number of twin studies in the past decade examining the relative contributions of genetic and environmental factors to psychopathology commonly seen in children and adolescents (Rutter et al., 1999). Either standardized diagnostic interviews or dimensional questionnaires have been used in such endeavors. One of the most commonly used dimensional instruments is the Child Behavior Checklist (CBCL; Achenbach, 1991), which consists of assessments on both competence scales (three subscales and one total competence) and behavioral/emotional problems (eight narrowband syndromes and three

broad-band syndromes). The results of the twin studies so far have indicated that the heritability for various childhood psychopathologies might be quite different across age and ethnic groups.

Similarly, twin studies examining the relative contributions of genes, common environment, and nonshared environment to schizotypal traits using biometric model fitting reported various results (Linney et al., 2003). Scores on the Schizotypal Personality Scale (usually referred to as the STA scale), which was designed to cover all aspects of schizotypy (Claridge & Broks, 1984), were found to have substantial contributions from additive genes (Claridge & Hewitt, 1987). However, the results of twin studies examining specific aspects of schizotypy, such as a series of scales designed by Chapman and colleagues (Chapman & Chapman, 1985), were conflicting.

To date, the majority of the existing twin studies on the CBCL or schizotypy have been conducted in Western countries. This article reports a study that aimed to evaluate the relative contributions of genes and environment to youths' competence, behavioral/emotional problems and psychometrically measured schizotypy in a sample of systematically ascertained adolescent twins/sibling pairs aged 12 to 16 years in Taiwan.

Recruitment Process

The participants were twins or same-sex sibling pairs recruited from the junior high schools in Taipei City between 1996 and 1998. The sampling of the participants has been described in detail elsewhere (Lin, 1999). In brief, a list of twins was solicited

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from the 71 junior high schools in Taipei City. Among them, 10 were unable to provide names of twins in their schools and another 10 provided fewer than five pairs of twins, which were not included in the study to improve the efficiency of data collection. In the remaining 51 schools, 609 twin pairs and their parents were invited to participate in the study. Among those invited, both members of 370 twin pairs and one member of another 14 pairs agreed to participate, yielding a participation rate of 60.8%. Among those invited, 533 parents agreed to participate and offered data. As monozygotic (MZ) twins are more common than dizygotic (DZ) twins in Taiwan (Chen et al., 1987), same-sex sibling pairs (ages vary within 2 years) from three schools were also recruited to increase sample size for the group with a kinship coefficient of .50. Among 79 identified sibling pairs, 56 pairs had at least one sibling agree to participate. The participating twins/sibling pairs were not different from singleton students, and concordant participant pairs were not different from discordant participant pairs in terms of demographic and personality features (Lin, 1999). Written informed consent was obtained from the students and their parents after a complete description of the study. Only those twins with unambiguous zygosity status (zygosity determination described below) and complete data for a specific measurement were included in each analysis, respectively.

Zygosity Determination

Zygosity of the first recruited 105 adolescent twin pairs were diagnosed with DNA typing with the polymerase chain reaction amplification of five loci, using the AmpliType PM PCR Amplification and Typing Kit with an accuracy rate of 99.0%. We then developed a zygosity questionnaire (Chen et al., 1999) for use in young twins and assessed its validity using the results of DNA diagnosis. A parsimonious model was established using stepwise logistic regression analysis of the 20 items of the questionnaire. The total accuracy rate of the model was 97.4 for parental reports (3 items: facial appearance, like two peas in a pod, and mistaken by strangers) and 95.6% for self-reports of adolescent twins (3 items: hair texture, like two peas in a pod, and mistaken by causal friends). If DNA diagnostic work-ups were applied to those with discordant reports either from themselves or from their parents, the accuracy rate increased to 100% for parental reports and 98% for self-reports. Thus, for the remaining twins, only those whose zygosity could not be determined because of the inconsistency of questionnaire reports either between twins or their parents underwent DNA diagnosis.

Measurements

The participating twins/siblings were asked to complete questionnaires, including demographic data, twins' physical similarity, body weight and height,

handedness, pubertal development, the Child Behavior Checklist (CBCL), the Schizotypal Personality Questionnaire (SPQ) and the Perceptual Aberration Scale (PAS), the Junior Eysenck Personality Questionnaire (JEPQ), the Tridimensional Personality Questionnaire (TPQ), and two neuropsychological tests: the Continuous Performance Test (CPT) and the Wisconsin Card Sorting Test (WCST). Buccal cells from mouthwash were collected for DNA typing. Both parents of the twins/siblings were asked to complete the twin similarity questionnaire if their offspring were twins and the PAS and SPQ for their own personality.

Child Behavior Checklist

The CBCL/4-18 consists of 20 competence items and 118 items to assess behavioral/emotional problems (Achenbach, 1991). The items of behavioral/emotional problems are scored on a 3-point scale (0 if not true, 1 if somewhat true or sometimes true, and 2 if very true or often true). Eight narrowband behavioral syndromes and three broadband behavioral syndromes were defined according to Achenbach. The broadband syndromes include Internalizing Problems (sum of Withdrawn, Somatic Complaints, and Anxious/Depressed), Externalizing Problems (sum of Delinquent Behavior and Aggressive Behavior), and Total Problems (all eight narrowband syndromes' scores summed together). The Chinese version of the CBCL, CBCL-C, was prepared via a two-stage translation (Huang et al., 1994). The applicability of the CBCL-C in assessing the competence and behavioral/emotional problems in Taiwanese adolescents has been demonstrated (Yang et al., 2000). Briefly, the internal consistency and 1-month test-retest reliability of the CBCL-C (all α s and reliabilities are greater than .60 except for Thought Problems) were satisfactory. In addition, both exploratory and confirmatory factor analysis provided some support for the validity of Achenbach's cross-informant model in the Taiwanese adolescents.

Perceptual Aberration Scale and Schizotypal Personality Questionnaire

The PAS (Chapman et al., 1978) contains 35 true-false items inquiring the experience of body-image distortions, while the SPQ (Raine, 1991) contains 74 true-false items that were grouped into nine subscales corresponding to all nine criteria of the schizotypal personality disorder in the *Diagnostic and Statistical Manual of Mental Disorders* (3rd ed., rev.; DSM-III-R). The reliability and validity of both scales in the Taiwanese population have been reported in detail elsewhere (Chen et al., 1997; Chen, Hsiao, et al., 1998). Briefly, both the SPQ and PAS were translated from English to Chinese by means of two-stage translation. The 1-week test-retest reliability coefficient (.86 for the SPQ and .80 for the PAS) and the internal consistency alpha (.95 for the SPQ and .84 for the PAS) in a singleton sample of adolescents ($n = 115$) were satisfactory.

The internal consistency of the schizotypy measurements in this study were adequate, with Cronbach's α

being .87 for the PAS, .92 for the SPQ total scale and ranging from .57 to .73 for its nine subscales. The confirmatory factor analysis of the SPQ data from the twins/sibling pairs in the present study revealed a good fit (goodness-of-fit index = .95, adjusted goodness-of-fit index = .90, normed fit index = .93, and Akaike's information criterion = 147.16) to a three-factor structure, which replicated the results from our previous adult and adolescent samples (Chen et al., 1997). These consist of Cognitive-Perceptual Dysfunction (including referential ideation, odd belief or magic thinking, unusual perceptual experience, and paranoid ideation), Interpersonal Dysfunction (including excessive social anxiety, lack of close friends, inappropriate or restricted affect, and paranoid ideation), and Disorganization (including odd speech and odd behavior).

Junior Eysenck Personality Questionnaire

The JEPQ contains 81 yes-no self-report items, consisting of three higher order factors, that is, Extraversion (E), Neuroticism (N), and Psychoticism (P), along with a Lie (L) scale for social desirability (Eysenck, 1975). The preparation of the Chinese version of the JEPQ was described elsewhere (Kuo, Chih, et al., 2004). Before administering the questionnaire, a pretest was performed to evaluate whether it was suitable for adolescents in Taiwan. The results of the pretest indicated that adolescents could answer these questions without apparent difficulty.

Tridimensional Personality Questionnaire

The TPQ (Cloninger, 1987) is a 100-item self-administered true-false instrument that consists of three high-grade dimensions, that is, Novelty Seeking (NS), Harm Avoidance (HA), and Reward Dependence (RD), each with four subscales. The Chinese version of the TPQ was prepared through a two-stage translation (Chen et al., 2002). In this study the examples provided at the end of three items (items 29, 47, and 51) were changed to better suit adolescents' experience in Taiwan (Kuo, Chih, et al., 2004). The results of a pretest indicated that adolescents could answer these questions also without obvious difficulty.

Continuous Performance Test

We used a CPT machine from Sunrise Systems (model version 2.20, Pembroke, MA, USA). The testing procedure has been described in detail elsewhere (Chen, Hsiao, et al., 1998; Chen et al., 1997). Briefly, numbers from 0 to 9 were randomly presented for 50 milliseconds each, at a rate of 1 per second. The probability of critical stimulus was set at 10%. Each student undertook two CPT sessions: the undegraded 1-9 task and the degraded 1-9 task. During the undegraded session, students responded to the target stimulus (the number 9 preceded by the number 1) by pressing a button. A total of 341 trials, 31 of them targets, were presented over a period of 5 minutes. During the degraded session, a pattern of snow was used to toggle background and foreground dots so that the image was not distinct.

Wisconsin Card Sorting Test

We employed a computerized version of the WCST. This version can be executed on a desktop or portable computer with a color screen (Tien et al., 1996). During the WCST, subjects were required to match response cards to the four stimulus cards along one of three dimensions (color, form, or number) by pressing one of the 1 to 4 number keys on the computer keyboard. Subjects were not informed of the correct sorting principle, nor were they told when the principle would shift during the test, but they were given feedback on the screen after each trial. Unlike the traditional WCST in which the test ends after 128 trials or six correct categories are achieved, the testing in this study continued until all 128 cards were sorted. The test results were scored by a computer software program and saved on diskettes.

Data Management and Analyses

Incorporating Nontwin Siblings with DZ Twins

In assessing whether DZ twins and same-sex sibling pairs could be pooled for subsequent analyses, the means and intraclass correlations for individual variables were compared separately for each gender. Whereas twins are of the same age, siblings are not. For this reason, we also examined age effects on each scale. We then incorporated same-sex sibling pairs with DZ twins and designated these as female DZ/SP group and male DZ/SP group, respectively.

Data Transformation

The skewed measurements were first normalized using the PROC RANK (SAS Institute Inc., 2000) and then standardized using PROC STANDARD separately for each sex. The transformation reduced nonnormality and standardized scores to unity variance and zero mean across sexes.

Model Fitting

We employed the Mx program (Neale, 1997) for the model fitting and parameter estimation for the full model and its reduced models. The likelihood-based 95% confidence intervals (CIs) for each parameter estimate were also computed (Neale & Miller, 1997).

Summary of Publications

Behavioral Problems

This work (Kuo, Lin, et al., 2004b) reported on a study to evaluate relative contributions of genetic and environmental factors to both competence scales and behavioral/emotional syndromes as assessed by the CBCL. In total, we had complete CBCL data from 279 twins/sibling pairs, consisting of 194 pairs of MZ twins (108 female, 86 male), 32 pairs of same-sex DZ twins (17 female, 15 male), 18 pairs of same-sex sibling pairs (10 female, 8 male), and 35 pairs of opposite-sex (OS) twins.

The Mx program was used to estimate parameters for a full model that contained effects from sex-specific additive genes, shared environment, and

nonshared environment for the majority of the scales. The shared environment in the full model was replaced with nonadditive genetic factors for some scales when indicated. All girls' competence and behavioral/emotional syndromes exhibited a substantial heritability ($h^2 > .4$), except for Social Competence and Withdrawn. For boys, although heritability was also greater than .4 for some scales (Social and School Competence, Thought Problems, Attention Problems, Delinquent Behavior, and Total Behavioral Problems), environmental influences, especially shared environment, were predominant for most of the scales (10 out of 15 scales). Genetic factors were important for explaining adolescent behavioral problems, especially for girls, while shared environmental influences could not be ignored for boys. Gender differences in heritability existed for various CBCL-based competence and behavioral/emotional problems.

Handedness

This study (Su et al., 2005) aimed to evaluate whether twinning influences handedness and the relative contribution of genetic and environmental factors to handedness. In total, we have complete handedness data from 357 twin/sibling pairs, consisting of 233 MZ twin pairs (128 female, 105 male), 46 same-sex DZ twin pairs (24 female, 22 male), 36 same-sex sibling pairs (23 female, 13 male), and 42 OS pairs. In addition, 1020 singletons, aged between 12 and 16 were systematically recruited from the junior high schools in Taipei. Both the directional and the consistent handedness index were calculated and used for the subsequent analyses. The direction and consistency of handedness in twins did not differ from that seen in singletons. Compared with the full model containing additive genes (A), shared (C), and nonshared (E) environment, both AE and CE models had equivalently acceptable fit. The contribution from additive genes in the AE model was estimated to be 16% (directional) and 13% (consistent) for the continuous handedness and 34% and 10% for the categorical one, whereas the corresponding contribution from shared environment in the CE model was 14% and 14% as well as 32% and 11%, respectively. Handedness in adolescents appears to be not influenced by twinning and not substantially heritable, whereas environmental factors, especially those not shared between siblings, are the most important ones for explaining individual variations.

Schizotypy

This study (Lin et al., in press) aimed to examine the relative contribution of genes and environment to psychometrically measured schizotypy and the causes for the covariation between different dimensions of schizotypy. In total, we have complete schizotypal trait data from 330 pairs of twins and 36 same-sex sibling pairs, including 241 MZ twin pairs (130 female, 111 male), 46 same-sex DZ twin pairs (24 female, 22 male), 36 same-sex sibling pairs (22 female, 14 male), and 43 OS

twin pairs. Univariate analyses of structural equation modeling using the Mx program showed that scores on these schizotypal measures were substantially heritable (h^2 ranging from 41% to 49%), with some genetic effects being nonadditive. All the different dimensions of schizotypy in adolescents appear to be substantially heritable. Multivariate analyses revealed common genetic factors linking between various traits of schizotypy, with bivariate heritability ranging from 50% to 65%. The proportion of the genetic contributions not shared with the other measures of schizotypy ranged from 24% for the Disorganization to 49% for the PAS scores. We concluded that there exist both common and specific genetic factors between the various dimensions of schizotypy, and at least half of their correlations were genetic in nature.

Future Work

Twin/sibling data on the JEPQ, the TPQ, the CPT, the WCST, and the other measurements will be further analyzed and submitted for publication. Collaborations with research groups with similar research areas/subjects of interest will be sought for the purpose of sharing data already collected or combining data analyses for cross-cultural study.

Furthermore, a pilot study to establish a twin cohort in east Taiwan has commenced through the enrolment in private and public primary and junior schools, and the matching of records obtained from residency and insurance sections of government. Emphasis will be placed particularly on enhancing the level of participation through email, newsletters, and websites offering twin related issues. In addition, the Taiwanese Adolescent Twin Registry Project (TATRP) is planned, aiming to establish the nationwide adolescent twin cohort in Taiwan in a systematic, longitudinal manner. Twins and their nontwin siblings and parents willing to participate in the project will undergo questionnaire-based assessments on zygosity, personality, mood condition, and environment, and reassessments will occur at two-year interval. The TATRP will offer not only a methodologically sound opportunity to investigate the genetic and environmental etiology of adolescent behaviors and affection, but also a model of data gathering and handling for a larger scale twin register in Taiwan in the future.

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