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11 Longitudinal Twin Study on Logic and Sensibility in Early Childhood: A Preliminary Report

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1. Introduction

Understanding the human mind and nature requires clarifying the integrative developmental process of logic and sensibility. During early childhood, logical ability (traditionally, intelligence or cognitive abilities) and sensibility (nonlogical characteristics such as sociability, emotionality, temperament, and personality) drastically differentiate and integrate in terms of form and content, and as a result, their individual differences increase and become more complex.

One of the most important research questions about this developmental process is its etiology: what is its main source? Classical research would use a "heredity or environment" framework to address the problem. In modern science, this simple dichotomy is considered invalid, and the common consensus is that both heredity and environmental factors interact and contribute to developmental processes. Based on this assumption, researchers in the field of human behavioral genetics are using the twin method and molecular biological techniques to investigate dynamic processes of interaction between genes and environment and how they affect psychological and behavioral traits (Plomin et al., 2003; Plomin et al., in press).

General findings of behavioral genetics can be summarized as follows

(Turkheimer, 2000):

1. All human behavioral traits are heritable.
2. Being raised in the same family has a smaller effect than genes.
3. A substantial portion of the variation in complex human behavioral traits is not accounted for by genes or family, but by random and nonsystematic environmental effects, including measurement errors.

These "three laws of behavioral genetics" are generally valid during infancy and early childhood, with a few exceptions. For example, the heritability of cognitive ability is relatively small in infancy and increases as the individual ages. In contrast, the family (shared) environmental effect is relatively larger in infancy and early childhood and becomes minimal as the individual ages to adolescence and adulthood (Wilson, 1983; McGue & Bouchard, 1993; Wadsworth et al., 1995). Wilson (1983) also found interesting synchronies in cognitive and emotional trajectories between identical twin siblings when they were young.

These findings suggest that heredity and environment have a dynamic relationship in the developmental process, especially when children are young. Revealing when and how relationships between genes and environment change in a given population is important because these findings can yield valuable educational implications and because relative variations in environmental and genetic conditions differ by culture.

We have just begun a longitudinal twin studies (with an expected 100 pairs) to investigate how and when genetic and environmental relationships between logical ability and sensibility vary and stabilize during early childhood. To our knowledge, this will be the fourth-largest longitudinal study using twins of this age, after the Netherlands Twin Register (NTR: 28000 pairs; http://www.tweelingenregister.org/), the English Twin Early Development Study (TEDS: 13,000 pairs; Oliver & Plomin, 2007), and the Boston University Twin Project (BUTP: an expected 300 pairs; http://www.bu.edu/psych/labs/butp.html). We will focus on cognitive abilities as logic and sociability as sensibility. We conducted a preliminary study of cognitive abilities using several pairs of twins to test our method and the validity of our measurements for use in further investigations of heredity and environmental processes.

We used the Japanese Kaufman Assessment Battery for Children (K-ABC; Kaufman & Kaufman, 1983; Matsubara et al., 1993). The K-ABC is one of a few tests that can be administered to children of preschool age in Japan.

Studies have confirmed the validity of K-ABC to test Japanese samples (Matsubara et al., 1993), but to date no studies of Japanese twins have applied the K-ABC.

The K-ABC operates on the assumption that cognitive activities are based on two types of information processing: sequential and simultaneous (Kaufman & Kaufman, 1983; Kamphaus & Reynolds, 1984). Simultaneous processing refers to a child's mental ability to integrate input simultaneously to solve a problem. The unifying characteristic of simultaneous processing is the mental synthesis of stimuli to solve the problem, independent of the input's sensory modality (Kamphaus & Reynolds, 1984). In contrast, sequential processing refers to a child's mental ability to arrange stimuli in sequential or serial order to solve a problem (Kamphaus & Reynolds, 1984). The K-ABC has another equally important component: the achievement scale. This scale measures abilities that complement the two types of processing. The achievement scale for children of preschool age measures verbal and mathematical abilities. Performance on the achievement scale can be considered an estimate of a child's successful application of their mental processing skills when acquiring knowledge from the environment (Kaufman & Kaufman, 1983; Kamphaus & Reynolds, 1984).

This report will provide results of our preliminary analyses regarding the following issues: whether we observed the same structure on which the K-ABC is based (i.e., simultaneous and sequential processing), whether simultaneous and sequential processing were correlated with the achievement scale, and whether we found a correlation between siblings (i.e., a correlation between performances of each pair of twins).

2. Method

2.1. Participants

Participants were twins and their parents living in the Tokyo area. The children had a mean age of 3.54 months (SD = 0.06). In this preliminary test, we used eight female–female twin pairs (MZ = 6 pairs, DZ = 2 pairs) and three male–male pairs (MZ = 2 pairs, DZ = 1 pair).

2.2. Procedures

Trained testers administered the K-ABC to all children in a laboratory, following the K-ABC Administration and Scoring Manual (Matsubara et al., 1993). Different testers administered the K-ABC to each child to avoid tester bias. Subtests were administered to children as follows:

2.2.1. Sequential Processing Subtests

Hand Movements

Children were required to imitate a series of hand movements in the same sequence as performed by the tester.

Number Recall

Children were required to repeat a series of digits in the same sequence as verbalized by the tester.

2.2.2. Simultaneous Processing Subtests

Magic Window

Children were required to identify a picture exposed by the tester by moving it past a narrow slit or "window," making the picture only partially visible at any one time.

Face Recognition

Children were briefly shown a photograph of one or two faces and then required to find the same faces in a group photograph.

Gestalt Closure

Children were required to name the object or scene pictured in a partially completed "inkblot" drawing.

2.2.3. Achievement Subtests

Expressive Vocabulary

Children were required to name the object pictured in a photograph.

Arithmetic

Children were required to answer a question using their knowledge of math concepts or the manipulation of numbers.

Riddles

Children were required to name the object or concept described by the tester.

2.3. Analysis

We conducted a factor analysis to determine whether the same structure assumed by the K-ABC (i.e., simultaneous and sequential processes) was found. Next, we examined whether simultaneous and sequential processes were correlated with achievement scale. Then, we examined whether the performance of each pair of twins was correlated.

3. Results

3.1. Descriptive Statistics

Table 1 shows means, standard deviations, and alphas of the standard scores of subtests.

Table 1. Means, standard deviations, and alphas of standard scores of subtests.

Subtests	Mean	*SD*	alpha
Hand Movements	9.21	3.36	0.76
Number Recall	10.29	4.20	0.63
Magic Window	10.83	3.02	0.52
Face Recognition	10.38	2.55	0.58
Gestalt Closure	10.29	3.41	0.63
Expressive Vocabulary	103.17	22.30	0.78
Arithmetic	96.46	16.08	0.80
Riddles	102.92	19.49	0.78

3.2. Factor Analysis

We conducted an exploratory factor analysis with a promax rotation on the standard scores of the five subtests (Hand Movements, Number Recall, Magic Window, Face Recognition, and Gestalt Closure). Eigenvalues suggested a two-factor solution. The first factor accounted for 25.87% of the total variance (eigenvalue = 1.84, alpha = .66) and loaded highly on Hand Movements and Number Recall. The second factor accounted for 19.27% of the total variance (eigenvalue = 1.26, alpha = .55) and loaded highly on Magic Window, Face Recognition, and Gestalt Closure (see Table 2). We termed the first factor "sequential processing" and the second "simultaneous processing," consistent with the assumption on which the K-ABC is based.

Because the internal consistencies of the two factors were moderate, we constructed a "sequential processing scale" by summing the standard scores of Hand Movements and Number Recall and a "simultaneous processing scale" by summing the standard scores of Magic Window, Face Recognition, and Gestalt Closure. In addition, we summed the standard scores of the Achievement subsets (Expressive Vocabulary, Arithmetic, and Riddles) because they had good internal consistency (alpha = .75); we termed this the "achievement scale." Table 3 shows the means and standard deviations of the sequential processing scale, the simultaneous processing scale, and the achievement scale.

Table 2. Factor loadings of subtests.

Subtests	First factor (sequential processing)	Second factor (simultaneous processing)
Hand Movements	1.01	–0.06
Number Recall	0.49	0.17
Magic Window	–0.07	0.71
Face Recognition	0.09	0.39
Gestalt Closure	0.11	0.52

Table 3. Means and standard deviations of the sequential processing scale, the simultaneous processing scale, and the achievement scale.

Scale	Mean	*SD*
Sequential processing scale	19.50	6.57
Simultaneous processing scale	31.50	6.55
Achievement scale	302.75	47.43

3.3. Inter-Scale Correlations

The achievement scale was significantly correlated with both the sequential processing scale and the simultaneous processing scale. The correlation between the sequential processing scale and the simultaneous processing scale was not significant (see Table 4).

Table 4. Inter-scale correlations among the sequential processing scale, the simultaneous processing scale, and the achievement scale.

Scale	Sequential processing	Simultaneous processing	Achievement
Sequential processing	-	.19	.46*
Simultaneous processing	.19	-	.44*
Achievement	.46*	.44*	-

Note: * $p < .05$

Table 5. Twin correlations among the sequential processing scale, the simultaneous processing scale, and the achievement scale.

		Twin 2		
	Scale	Sequential processing	Simultaneous processing	Achievement
Twin 1	Sequential processing	.61*	.21	.45
	Simultaneous processing	.04	.51^{+}	.21
	Achievement	.50	.02	.54^{+}

Note: * $p < .05$; $^{+}p < .1$

3.4. Sibling Correlation

The sequential processing scale of Twin 1 was significantly correlated with that of Twin 2. Correlations between the simultaneous processing scales of Twin 1 and Twin 2 and between the achievement scales of Twin 1 and Twin 2 were close to significant, but correlations between different scales of twins were not significant (see Table 5).

4. Discussion

This report provides the purpose, method, and preliminary results of our early childhood twin project in its earliest stage. Our main goal is to reveal a dynamic process of genes and environment in the development of logic and sensibility during early childhood using the twin method. In this preliminary test, we administered the K-ABC test, which measures sequential and simultaneous information processing, to 11 pairs (22 individuals) of twins aged 3.5 years.

Even with this small sample size, each subtest score of the K-ABC showed fairly acceptable reliability coefficients. Inter-scale correlations provided theoretically reasonable relationships among variables; the sequential and

simultaneous processes were independent of each other, and were both correlated with achievement score. Twin correlations for sequential, simultaneous, and achievement scores were substantial, indicating some familial influences, although this small sample size makes it impossible to estimate how genetic and environmental factors influenced these familial effects.

We plan to collect data from at least 150 pairs of twins. No studies of twins in Japan have ever had such a large sample size. We anticipate that the results will reveal the etiology and developmental changes of cognitive abilities among Japanese preschool children. In addition, we expect to produce data comparable to those produced by studies from other countries: the Netherlands (NTR), the United Kingdom (TEDS), and the United States (BUTP).

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