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17 A Twin Study on Logic and Sensibility in Early Childhood: Findings from Univariate Behavior Genetic Analyses.

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Introduction

Understanding the process whereby cognitive and sociocognitive functioning develop during early childhood can contribute to knowledge about logic and sensibility because cognitive functioning is essential to the ability to think logically, sociocognitive functioning is essential to the ability to think sensibly, and both undergo dramatic developmental shifts during early childhood. In addition, individual differences characterize the development of these functioning even at early stages of development.

One approach to understanding the development of cognitive and sociocognitive functioning involves using a behavior genetics perspective to clarify their etiology. According the "three laws of behavior genetics" proposed by Turkheimer (2000), all human behavioral traits are heritable, and the effects of family environment are smaller than those of genes. However, this notion may not hold for infancy and early childhood. For example, the heritability of cognitive ability is relatively small during infancy but increases with age. In contrast, the impact of the family (shared) environment is relatively stronger during infancy and early childhood. Thus, the relative impact of genetic and environmental influences on psychological traits is not stable but rather changes, especially during younger ages.

In this report, we use the perspective of sociocognitive functioning to examine the skills of theory of mind and executive functioning. Theory of mind refers to the ability to attribute mental states (such as beliefs, desires, and intentions) to oneself and to others. Executive functioning refers to the processes responsible for the higher-level action control (e.g., planning, inhibition, coordination, and control of action sequences) necessary for focusing on and achieving a specified goal, especially in the context of potential distractors (Perner & Lang, 1999). These two abilities are essential for maintaining adaptive social life.

Compared to research on the etiology of cognitive development during early childhood (e.g. McGue., et al., 1993; Cherny, et al., 1997; Eley, et al., 1999), there are a fewer studies on the etiology of sociocognitive functioning and the results from those studies are not consistent.. For example, one study reported a substantial genetic effect on individual differences in theory of mind (Hughes & Cutting, 1999), whereas another study found that environmental effects explain the majority of such individual differences (Hughes, Jaffee, Happe, Taylor, Caspi, & Moffitt, 2005). Recent evidence on executive functioning (Freedman, e al., 2008) has shown that latent variables of three subsystems governing executive functions (those inhibiting dominant responses, updating working memory representations, and shifting between task sets) are influenced by a highly heritable (99%) common factor. There is, however, little research on the etiology of executive functioning during early childhood.

The correlation between theory of mind and executive functioning has been consistently confirmed (Carlson & Moses, 2001). Although the reasons underlying this correlation have not yet been fully investigated, such findings have not been attributed to methodological features common to the assessment tasks (Perner, Lang, & Kloo, 2002). Rather, it has been suggested that theory of mind and executive functioning are interdependent; an understanding of mental states as causally efficacious is required for executive inhibition, and executive functioning represents a primary way to exercise a theory of mind at this early stage of development (Perner & Lang, 1999). Thus, in this report we propose that the abilities deriving from theory of mind and executive functioning are integrated in the service of sociocognitive functioning.

In this report, we will present the results of our preliminary analyses

concerning the etiology of the development of cognitive and sociocognitive functioning.

Method

Participants

Participants were twins and their parents living in the Tokyo area. The mean age of children was 42.12 months (SD = 1.02). Numbers of twin pairs are shown in Table 1.

Table 1. Numbers of pairs of twins.

	Male-male	Female-female	Total
Monozygotic twins	19	20	39
Dizygotic twins	19	19	38
Total	38	39	77

Measures

Trained testers conducted the following evaluations on all children in a laboratory setting. Different tests were administered by different testers to each twin in order to avoid tester biases.

Cognitive functioning: Kaufman Assessment Battery for Children (K-ABC)

We conducted the K-ABC following the K-ABC Administration and Scoring Manual (Matsubara et al., 1993). We have reported elsewhere that our data have the same factor structure as that assumed by the K-ABC (i.e., sequential processing and simultaneous processing; see Fujisawa & Ando, 2008 for details). We used standard scores for the sequential and simultaneous processing scales.

Sociocognitive functioning

Theory of mind tasks

We included the following tasks in our evaluation: two tasks of location false belief, contents false belief task, and two tasks of appearance reality (Flavell et al., 1983; Carlson & Moses, 2001). We summed the number of correct answers for each task (range: 0-5).

Executive functioning tasks

The following tasks were included in our evaluation: card sorting (Frye et al., 1995; Carlson & Mose, 2001), Tower building blocks (Kochanska et al., 1996), and present delay (Kochanska et al., 1996; Carlson & Mose, 2001; Carlson, 2005). We summed the number of correct answers in response to the card sorting task (range: 0-5). We calculated the proportion of blocks that the tester placed of the total number of blocks in the Tower building blocks (range: 0-1). We recorded how long the child could wait to measure present delay (range: 0-60 sec).

Because of the various kinds of scales involved in tasks related to sociocognitive functioning, we conducted a principal component analysis. We used factor scores of children as a measure of sociocognitive functioning for the following analyses.

Analyses

Within-pair correlations and univariate genetic analyses for sequential processing, simultaneous processing, and sociocognitive functioning.

We investigated the extent to which genetic and environmental factors account for individual differences in sequential processing, simultaneous processing, and sociocognitive functioning. We first examined within-pair correlations for each measure and then conducted separate univariate genetic analyses for each measure.

According to theories of behavioral genetics, individual differences arise from genetic and environmental factors. Environmental factors

include shared environmental factors, whereby children growing up in the same family tend be similar, and nonshared environmental factors, whereby each child in the same family has unique experiences that yield differences among children in the same family. Quantitative genetic research assumes that MZ twins are genetically identical and that therefore the correlation between the genetic factors of Twin 1 and Twin 2 is 1.0. In contrast, DZ twins have only half their genes in common, and thus the correlation between the genetic factors of Twin 1 and Twin 2 is 0.5. By definition, assumptions concerning environmental factors are as follows: the correlation between the shared environmental factors associated with Twin 1 and Twin 2 is 1.0 for both MZ and DZ twins growing up in the same family; the correlation between the nonshared environmental factors associated with Twin 1 and those associated with Twin 2 is zero for both MZ and DZ twins because nonshared environmental factors uniquely influence each twin regardless of zygosity.

Based on these assumptions, a higher within-pair correlation for MZ twins than for DZ twins would indicate that genetic factors account more substantially for individual differences on a given measure. Furthermore, the effects of three latent factors (i.e., genetic factors, shared environmental factors, and nonshared environmental factors) can be estimated by quantitative genetic structural equation modeling in which covariance matrices between MZ pairs and DZ pairs are used (for details, see Neale & Cardon, 1992). We used Mx software (Neale, Boker, Xie & Maes, 2002) for univariate genetic analyses.

Results

Descriptive statistics

Descriptive statistics of raw scores of each measure were shown in Table 2.

Principal component analysis for sociocognitive functioning tasks

Sociocognitive functioning was determined via principal component analysis (PCA) on theory of mind and executive functioning tasks. Only

Table 2. Means and standard deviations of measures.

Measures	Mean	SD
Sequential processing	94.35	16.70
Simultaneous processing	99.61	17.59
Theory of mind tasks	0.93	1.00
Card sorting task	3.59	1.37
Building brocks task	0.61	0.12
Present delay task (sec)	35.01	24.39

one factor emerged from the PCA with an eigenvalue of 1.46. This factor explained 36.46% of the variance in theory of mind and executive functioning tasks and was characterized by high positive loadings for theory of mind tasks (.71), the card sorting task (.50), the tower building blocks task (.42), and the present delay task (.73). We labeled this factor as sociocognitive functioning, and participants' factor scores were used in the subsequent analyses.

Within-pair correlations and univariate genetic analyses

Within-pair correlations (i.e., the correlations between scores for Twin 1 and those for Twin 2) for sequential processing, simultaneous processing, and sociocognitive functioning are shown in Table 3. All within-pair correlations were significant. Those correlations were similar regardless of zygosity, suggesting that environmental factors, rather than genetic factors, accounted for the individual differences in these measures. Results of

Table 3. Within-pair correlations of sequential processing, simultaneous processing and sociocognitive functioning.

	Within-pair r	
	MZ	DZ
Sequential processing	.52**	.58**
Simultaneous processing	.63***	.56***
Sociocognitive functioning	.53**	.59**

Note. *** $p<.001$. ** $p<.01$.

Table 4. Estimates of variance components accounting for individual differences in sequential processing, simultaneous processing and sociocognitive functioning.

	Variance estimates		
	Heritability	Shared environment	Nonshared environment
Sequential processing	0.00 (0.00-0.53)	0.57 (0.08-0.72)	0.43 (0.27-0.63)
Simultaneous processing	0.12 (0.00-0.71)	0.49 (0.00-0.72)	0.39 (0.24-0.58)
Sociocognitive functioning	0.01 (0.00-0.71)	0.56 (0.00-0.73)	0.43 (0.23-0.66)

Note. Numbers in parenthesis are 95% confidence intervals.

univariate genetic analyses for sequential processing, simultaneous processing, and sociocognitive functioning supported this finding; for all measures, estimates for genetic factors were very low, whereas estimates for shared and nonshared environmental factors were substantial (Table 4).

Discussion

We reported the preliminary results of univariate behavior genetic analyses for cognitive and sociocognitive functioning during early childhood. We found that twin correlations for all measures did not differ substantially according to zygosity. Genetic effects were small, whereas shared and nonshared environmental effects were substantial for all measures.

In spite of the relatively small sample size for a behavior genetic study, our preliminary results are consistent with the general notion that environmental effects substantially account for individual differences in various phenotypes during early childhood. However, two possibilities remain concerning the major effects of environmental factors on cognitive and sociocognitive functioning. First, the characteristics of our sample families might have affected the findings. Participants in our project were primarily two-parent families and were particularly cooperative (as evidenced by their coming to our laboratory on Sundays). This may be consistent with the interpretation provided by Hughes et al (2005) of the

substantial environmental influence on the acquisition of theory of mind. They suggested that the very low SES of the families included in their study could have increased their study's sensitivity to shared environmental effects (Hughes et al., 2005). Second, the age of the twins in our project (mean = 42 months) could have affected the findings. The relative salience of genetic and environmental influences on individual differences in cognitive and sociocognitive functioning may be related to development. Normative life events experienced by children, such as transition to elementary school, accumulate with age. It is highly likely that genetic effects will be potentiated by these experiences. We are planning to collect longitudinal data when the twins are approximately 60 months old in order to examine this possibility.

References

Carlson, S. M., & Moses, L. J. (2001). Individual differences in inhibitory control and children's theory of mind. *Child Development*, *72*, 1032-1053.

Cherney, S.S., Fulker, D.W., & Hewitt, J.K. (1997). Cognitive development from infancy to middle childhood. In: Sternberg, R. J., Grigorenko, E.L. Intelligence, heredity, and environment.; New York, NY, US: Cambridge University Press, pp. 463-482.

Eley, T.C., Bishop, D.V. M., Dale, P. S., Oliver, B., Petrill, S.A., Price, T.S., Saudino, K. J., Simonoff, E.,Stevenson, Ji., Plomin, R., & Purcell, S. (1999). Genetic and environmental origins of verbal and performance components of cognitive delay in 2-year-olds. *Developmental Psychology*, *35*, 1122-1131.

Friedman, N. P., Miyake, A., Young, S. E., DeFries, J. C., Corley, R. P., Hewitt, J. K. (2008). Individual differences in executive functions are almost entirely genetic in origin. *Journal of Experimental Psychology, General*, *137*, 201-225.

Fujisawa, K. K., & Ando, J. (2008). A longitudinal twin study on logic and sensibility in early childhood: A preliminary report. CARLS Series of Advanced Study of Logic and Sensibility, pp. 191-200.

Hughes, C., & Cutting, A. L. (1999). Nature, nurture, and individual differences in early understanding of mind. *Psychological Science*, *10*, 429-432.

Hughes, C., Jaffee, S. R., Happe, F., Taylor, A., Caspi, A., & Moffitt, T. E. (2005). Origins of individual differences in theory of mind: from nature to nurture? *Child Development, 76*, 356-370.

Kaufman, A. S., & Kaufman, N. L. (1983). *Kaufman Assessment Battery for Children*.

McGue, M., Bouchard,T. J. Jr., Iacono,W. G., & Lykken, D. T. (1993). Behavioral genetics of cognitive ability: A life-span perspective. In: R. Plomin, & G. E. McClearn (eds.) Nature, nurture, and psychology. Washington:APA.

Matsubara, H., Fujita, K., Maekawa, H., & Ishikuma, T., (1993). *Japanese Kaufman Assessment Battery for Children*. Maruzen, Japan.

Neale, M. C., & Cardon, L. R. (1992). *Methodology for genetic studies of twins and families*. Dordrecht, the Netherlands: Kluwer.

Neale, M. C., Boker, S. M., Xie, G., & Maes, H. H. (2002). *Mx: Statistical modeling* (6th ed.). Richmond, VA: Virginia Commonwealth University, Department of Psychiatry.

Perner, J., & Lang, B. (1999). Development of theory of mind and executive control. *Psychological Science*, *3*, 337-344.

Perner, J., Lang, B., & Kloo, D. (2002). Theory of mind and self-control: more than a common problem of inhibition. *Child Development*, *73*, 752-767.

Turkheimer, E. (2000). Three laws of behavioral genetics and what they mean. *Current Directions in Psychological Science*, *9*, 160-64.

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