Summary: The structure and stability of Intelligence

In this study, six measures of cognitive abilities assessing two major domains of intelligence were administered to 209 twin pairs at the ages of 5, 7, and 10 years (RAKIT; Bleichrodt et al., 1984). The factor structure of cognitive abilities was studied both by exploratory and confirmatory factor analyses. The longitudinal design of the study permitted the investigation of configural invariance over time, and stability of individual differences in phenotypic scores on the six subtests. The availability of twin data allowed for the exploration of the genetic and environmental contributions to the phenotypic structure of cognitive abilities.

A common factor model with two correlated factors was found to fit the phenotypic covariance matrix of the RAKIT. This factor model was found to fit well and to be amenable a sensible interpretation at ages 5, 7, and 10. The correlation between the verbal and nonverbal group factors was estimated between .40 and .49 at these ages. Age-specific genetic analyses revealed that the genetic covariance matrix, like the phenotypic covariance matrix, was consistent with a two common factor model. A single common factor, without residuals, fitted the shared environmental covariance matrix. The unique environment operated in a subtest-specific manner, that is, these effects contributed only to the residual variances of the test scores. The genetic and environmental factor structures were found to be identical across age.

The factor structure as described was retained in the analyses of the longitudinal data. The genetic nonverbal and verbal factors correlated moderately at each age (.25 at age 5, .28 at age 7, .30 at age 10). The genetic and environmental contributions to the total variance of each subtest at each age are reported in Table 8.1. The genetic contributions to the total variance of each subtest either did not change (Discs, Hidden Figures, Idea Production) or increased (Exclusion, Verbal Meaning, Learning Names) in importance from age 5 to age 10. With the exception of Verbal Meaning, the shared environment contributed little to the phenotypic subtest variance at each age. In contrast, the unique environment explained a relatively large proportion of the total subtest variance. Estimates varied between 22% to 64% depending on subtest and age of measurement. These components of variance include measurement error.

The phenotypic stability of performance on the intelligence subtests was estimated between .35 and .55 from ages 5 to 7, and 7 to 10. These correlations did not vary in any perceivable consistent manner between verbal and nonverbal subtests, or between age intervals. The longitudinal analyses revealed that the stability of subtest performance was found to be mainly due to stable genetic influences. Shared environmental influences con-

tributed to this phenotypic stability, but the contribution was relatively small, and waned as children grew older. Support for the differentiation hypothesis, which states that the inter-correlation among dimensions of cognitive abilities decrease with increasing age, was absent at the genetic and environmental level.

Table 8.1: Percentages of total variance explained by additive genetic (a^2), shared environmental (c^2), and unique environmental factors (e^2).

Subtest	age	a^2	c^2	e^2
	5	38	19	43
Exclusion	7	40	5	55
	10	58	7	35
	5	46	3	51
Discs	7	58	5	37
	10	44	4	52
	5	48	11	41
Hidden Figures	7	37	14	49
	10	48	8	44
	5	21	39	40
Verbal Meaning	7	19	17	64
	10	42	32	26
	5	53	17	30
Learning Names	7	39	32	29
	10	74	4	22
	5	58	5	37
Idea Production	7	58	4	38
	10	60	4	36

Summary: The development of Overactivity and Attention Problems

When twins were aged 3, 7, 10, and 12 years, their parents were asked to complete the CBCL on both twins. At age 3, twins were rated on the Overactivity scale, a syndrome scale of the CBCL/2-3 (Achenbach, 1992) identified by Koot and colleagues (1997). At ages 7, 10, and 12, twins were rated on the Attention Problem scale of the CBCL/4-18 (Achenbach, 1991). Maternal data from complete birth cohorts 1986 through 1993 of 3- and 7-year-old twins were analyzed. Of these cohorts, some twins had yet to reach the age of 10 and 12 years when the present study of Overactivity and Attention Problems began. Resulting data included 11938 reports of 3-year-old twin, 10657 reports of 7-year-old twins, 6192 reports of 10-year-old twins, and 3124 reports of 12-year-old twins.

Boys displayed much more Overactive problem behavior at age 3 and Attention Problem behavior at ages 7, 10, and 12 than girls. Between 2% and 7% of the children displayed extreme Overactive and Attention Problem behavior with a higher prevalence rate in boys at each age.

Genetic analyses revealed a large estimate of heritability of Overactive and Attention Problem behavior. The relative genetic and unique environmental contributions are listed in Table 8.2. A very consistent pattern emerged from these results. Broad heritability (i.e., the sum of additive genetic and genetic dominance effects) is estimated between 70% and 74%. The residual variance in Overactivity and Attention Problems is explained by unique environmental influences, i.e., environmental influences not shared by individuals of the same household.

Table 8.2: Percentages of total variance explained by additive genetic (a^2), genetic dominance (d^2), and unique environmental effects (e^2). In each cell two estimates are given, one for boys and one for girls.

Problem scale	age	a^2	d^2	e^2
Overactivity *	3	50% - 41%	22% - 33%	28% - 26%
Attention Problems	7	33% - 57%	39% - 16%	28% - 27%
Attention Problems	10	41% - 48%	31% - 25%	28% - 27%
Attention Problems	12	40% - 54%	30% - 18%	30% - 28%

Note: * the presence of a contrast effect was suggested at age 3. The prevailing interpretation of the contrast effect is that parents stress the difference in overactive behavior between their twins. In genetic analyses, the contrast effect is difficult to discern from the genetic dominance effect.

The transition from Overactive behavior at age 3 into Attention Problems at age 7 was characterized by a moderate degree of stability (around .40). The stability of Attention Problems from age 7 to age 12 was found to be much larger (around .70). The degree of stability of these behavior problems was found equal in both sexes. Across the entire age range from age 3 to age 12, genetic effects accounted for the observed stability in Overactivity / Attention Problems (range from 76% to 92%). Genetic and environmental contributions to the phenotypic covariance did not differ over the age-intervals. No consistent difference in these contributions emerged between boys and girls. Further, it appeared that boys and girls share the same set of genes and environmental effects.