A 14-year cohort-sequential study of
covariant hormonal, body, brain, ability, and personality development
in 420 8-18 year old boys and girls,
selected for age, sex, and socio-economical status of their parents.

by

Helmuth Nyborg

Research Project.

International Research Center for

Psychoneuroendocrinology

Institute of Psychology

University of Aarhus

Aarhus, Denmark

March 1993

The Skanderborg project:
A 14 year cohort-sequential study of
420 8-18 year old boys and girls.

Year studied:

Born							Type of study:
1960					1976		1. Cross-sectional
1962				1976			
1964			1976				
1966		1976					
1968	1976	1978	1980	1982	1984	1986	Longitudinal study
1970							
1972						1990	2. Cross-sectional
1974					1990		
1976				1990			
1978			1990				
1980		1990					
1982	1990						
Age	8	10	12	14	16	18	

(Time-lag arrows are shown across the diagonals.)

Hormone measures: Free and bound estradiol, estrone sulphate, free and bound testosterone, DHEAS, DHT, 4AH, FSH, LH, SHBG.
Anthropometric measurements.

Dichotic listening, tachistoscopic dot counting.

Perceptuo-motor tests: Pursuit-rotor test, tapping.

Rod-and-frame test, Embedded-Figures test, Mental rotation test, Road-Map test, WISC or WAIS, School grades.

Eysenck Personality questionaire, PRF Andro scale, Newcombe Early Experiences and Interest.

Educational and occupational choices.

Anthropometric measures, pubertal staging, bone maturation, and laterality measures

Pre-school measures:
1. Birth lenght
2. Birth weight
3. Vision, hearing etc.

Repeated height/weight measures
from birth to school age
Developmental or other defects, major illness

Childhood measures (consecutive years):
4. Standing height from sole to top of head
5. Sitting height
6. Height from sole to pubic bone
7. Head circumference
8. Arm span
9. Breast span
10. Circumference of biceps
11. Internipple distance
12. Inner canthal distance
13. Outer canthal distance
14. Bi-acromial diameter
15. Bi-cristal diameter
16. Strenght of fingers and hand
17. Cubitus valgus
18. Genus valgus
19. Size of testes

At time of psychological testing

of preferred arm

Dynamometer

Prader's orchiometer

Pubertal stage:
20. 3 standardized nude photos: Front, side, behind

For estimation of pubertal stage ad modum
Tanner, and body typing ad modum Sheldon

Biological age:

21. X-ray of left hand

For estimation of bone age (skeletal
maturation) ad modum Tanner-Whitehouse
(20-bone-scale)

Laterality measures:
22. Handedness
23. Eye dominance

Figure 3. Consecutive biological measures at birth and unto adulthood, in accordance with prescriptions by Tanner (1966).

Tests	Measure
Visuo-spatial tasks:	
1. Rod-and-frame test	Field dependency -
2. Embedded-figures test	psychological differentiation.
3. Money's Road-Map test	Left-right discrimination.
4. Vandenberg's version of the	
Metzler-Shepard test [*]	Mental rotation.
Perceptuo-Motor task:	
5. Pursuit-Rotor test	Hand-Eye coordination.
Brain functional specialization tasks:	
6. Dichotic Listening test	Lateralization of language.
7. Tachistoscopic Dot Counting test	Non-Verbal brain lateralization.
Spatial experiences during childhood:	
8. Danish version of Newcombe's	Spare time interests during childhood.
questionnaire [*]	
Personality:	
9. Danish versions of Eysenck's	Psychoticism, Extraversion,
Personality Questionnaire:	Neuroticism, and
Junior and Adult versions[*]	Social desirability
10. Terman-Miles Gender	Teacher's rating of conformity to sex
Preference scale	stereotypic norms
11. PRF Andro Scale (Berzins)[*]	Self-reported masculinity, femininity, and androgyny
Intelligence:	
12. Wechsler Intelligence Scale for	Intelligence in childhood
Children	
Wechsler Adult Intelligence Scale	Adult intelligence

Figure 2. Overview of types of test used in the study. Instructions and other test materials were translated into danish, and the danish translation was again re-translated in some cases [*] into the original language in cooperation with the constructor of the test.

Radioimmunoassays

Gonadal androgens:
1. Free + protein bound Testosterone   t
2. Free testosterone   Free t

Adrenal androgens:
3. Dihydrotestosterone   DHT
4. Δ - 4 - Androstendione   4-AD
5. Dehydro - epi - androsteronesulphate   DHAS

Gonadal estrogens:
6. Free + protein bound Estradiol E_2
7. Non - SHBG bound Estradiol E_2
8. Free Estradiol   Free E_2

Adrenal estrogens:
9. Free + protein bound Estrone E_1
10. Estrone Sulphate E_1SO_4

Pituitary hormones:
11. Follicle - Stimulating Hormone   FSH
12. Luteinizing Hormone   LH

Globulin:
13. Sex-Hormone - Binding - Globulin   SHBG

Figure 4. Overview of radioimmunoassaying. For boys, one blood sample (4 WR tubes) is collected between 10 a.m. and 2 p.m. For premenstrual girls, blood is sampled between 10 a.m. and 2 p.m. For menstruating girls, two blood samples are taken: One on the 8th. day (±1 day) after 1st. menstrual flow day, and one on the 22nd. day (±1 day) after 1st. menstrual flow day.

Table 3. Sex differences in 8-14 years old boys and girls in 20 independent variables, represented by means, t-values, effect sizes, point-biserial correlations, and variances (N=325).

Variable	Mean differences						Differences in variability				
	Mean Boys	Mean Girls	Difference Boys-Girls	t-test p	Effect size d	Point-biserial correlation	Boys sd	Girls sd	Average sigma Boys-girls	Variance ratio F	Variance p
RFT Frame dependence (signed error, inv.)	-4,98	-5,56	0,57	0,29	0,09	0,04	6,52	6,92	6,73	1,10	0,56
RFT response variability (error, inv.)	-2,71	-3,20	0,49	0,03	0,18	0,10	2,53	2,93	2,74	1,01	0,95
RFT Field dependence (unsigned error inv.)	-6,25	-7,40	1,15	0,03	0,17	0,09	6,29	6,81	6,56	1,21	0,23
Embedded-Figures test (Sec/fig inv.)	-76,04	-77,33	1,29	0,79	0,03	0,01	49,85	46,02	47,97	1,01	0,97
Money left-right discrim.test (error inverted)	-7,73	-9,04	1,31	0,02	0,20	0,11	6,86	6,39	6,63	1,14	0,46
Mental Rotation (Figs. found. corr. f. guess.)	5,91	4,43	1,49	0,00	0,48	0,29	3,13	3,03	3,08	1,14	0,49
Tapping (Left hand)	266,51	245,40	21,11	0,01	0,36	0,21	61,32	55,87	58,57	1,22	0,39
Tapping (Right hand)	298,69	289,53	9,16	0,32	0,14	0,08	66,36	60,94	63,71	1,15	0,54
Oral fluency	11,25	11,35	-0,10	0,90	-0,02	-0,01	5,32	5,16	5,24	1,22	0,38
WISC Information	10,17	8,79	1,38	0,00	0,47	0,29	3,17	2,61	2,90	1,60	0,02
WISC Comprehension	10,75	9,73	1,03	0,04	0,28	0,16	3,57	3,66	3,62	1,06	0,80
WISC Arithmetic	11,32	10,71	0,61	0,11	0,22	0,12	2,78	2,75	2,76	1,01	0,97
WISC Similarities	11,87	11,39	0,48	0,27	0,15	0,08	3,45	2,84	3,16	1,55	0,04
WISC Vocabulary	12,24	10,82	1,41	0,00	0,46	0,28	3,44	2,62	3,06	1,96	0,00
WISC Digit Span	9,53	9,73	-0,20	0,58	-0,08	-0,04	2,47	2,65	2,56	1,07	0,73
WISC Picture Completion	13,25	12,16	1,10	0,01	0,37	0,21	2,61	3,34	3,00	1,54	0,04
WISC Picture Arrangement	12,49	11,55	0,94	0,02	0,31	0,18	2,72	3,30	3,03	1,15	0,73
WISC Block Design	14,20	13,46	0,74	0,08	0,24	0,13	2,89	3,23	3,07	1,33	0,18
WISC Object Assembly	12,85	12,89	-0,04	0,92	-0,01	-0,01	2,63	2,77	2,70	1,07	0,75
WISC Coding	10,83	12,36	-1,52	0,00	-0,55	-0,18	2,77	2,76	2,76	1,02	0,92
Average Effect Size					0,18						
Average IQ equivalent					2,62						

Significant p values are italicized, with blue for boys scoring superior and red for girls scoring superior

Table 3. Sex differences in 16+ years old males and females in 20 independent variables, represented by means, t-values, effect sizes, point-biserial correlations, and variances (N=52).

Variable	Mean differences					Differences in variability				Variance F ratio	Variance p
	Mean Boys	Mean Girls	Difference Boys-Girls	t-test p	Effect Size d	Point-biserial correlation	sd Boys	sd Girls	Average sigma Boys-girls		
RFT Frame dependence (signed error, inv.)	-1,72	-2,96	1,25	0,12	0,43	0,25	2,43	3,35	2,92	1,90	0,10
RFT Response variability (error, inv.)	-1,46	-1,94	0,47	0,13	0,42	0,25	0,70	1,44	1,13	4,24	0,00
RFT Field dependence (unsigned error inv.)	-2,63	-3,71	1,08	0,14	0,41	0,24	1,95	3,20	2,65	2,70	0,01
Embedded-Figures test (Sec/fig inv.)	-38,21	-42,27	4,06	0,71	0,13	0,07	30,59	33,44	32,05	1,28	0,54
Money left-right discrim. test (error inverted)	-1,39	-3,45	2,06	0,04	0,53	0,33	2,96	4,61	3,88	2,42	0,02
Mental Rotation (Figures found, corrected)	8,11	6,56	1,56	0,05	0,68	0,44	1,81	2,71	2,30	1,12	0,76
Tapping (Left hand)	313,29	289,00	24,29	0,02	0,60	0,38	38,11	42,88	40,57	1,27	0,52
Tapping (Right hand)	353,68	341,35	12,32	0,24	0,30	0,17	40,06	41,72	40,90	1,08	0,83
Oral fluency	14,23	14,61	-0,39	0,76	-0,08	-0,04	5,19	4,51	4,87	1,32	0,45
WAIS Information	10,90	10,00	0,90	0,10	0,43	0,25	2,01	2,22	2,12	1,23	0,58
WAIS Comprehension	10,10	10,71	-0,61	0,39	-0,22	-0,10	2,71	2,85	2,78	1,11	0,78
WAIS Arithmetic	11,13	10,84	0,29	0,62	0,13	0,07	2,29	2,31	2,30	1,02	0,96
WAIS Similarities	13,19	12,23	0,97	0,18	0,34	0,20	2,65	2,95	2,81	1,24	0,56
WAIS Digit Span	9,94	9,55	0,39	0,53	0,16	0,09	2,48	2,38	2,43	1,08	0,83
WAIS Vocabulary	11,58	10,90	0,68	0,17	0,35	0,20	1,63	2,18	1,92	1,79	0,11
WAIS Digit Symbol	11,13	12,61	-1,48	0,03	-0,56	-0,19	2,68	2,60	2,64	1,06	0,87
WAIS Picture Completion	12,97	12,00	0,97	0,10	0,43	0,26	2,14	2,38	2,26	1,24	0,56
WAIS Block Design	14,29	14,06	0,23	0,74	0,08	0,04	2,60	2,76	2,68	1,13	0,75
WAIS Picture Arrangement	11,94	11,84	0,10	0,88	0,04	0,02	2,50	2,41	2,46	1,08	0,84
WAIS Object Assembly	13,52	13,68	-0,16	0,81	-0,06	-0,03	2,64	2,56	2,60	1,07	0,86
Average Effect Size					0,26						
Average IQ equivalent					3,94						

Significant p values are italized, with blue for boys scoring superior and red for girls scoring superior

Figure 7.

Factor loadings for 325 8-14 year old boys and girls on hierarchical orthogonal components (Schmid-Leiman) for 21 variables, with eigenvalues > 1. Point-biserial correlations (adjusted for inequal Ns and SDs), were factored in to indicate loading of sex on each of the dimension

	g Second. 1	Mental Rotation Second. 2	Verbal Primary 1	Visualization and Dexterity Primary 2	Spatial Orientation Primary 3	Speed and Accuracy Primary 4	Short-term Memory Primary 5
RFT Frame dependence (signed error, inv.)	0,413	0,183	-0,042	0,088	-0,665	0,147	-0,060
RFT Response variability (error inv.)	0,126	0,274	-0,063	0,597	-0,186	0,030	-0,337
RFT Field dependence (unsigned error inv.)	0,395	0,305	-0,042	0,383	-0,587	0,110	-0,220
Embedded-Figures test (sec/fig inv.)	0,583	0,128	-0,015	0,634	0,000	0,041	0,147
Money left-right discrimination test (Inv.)	0,452	0,113	-0,234	0,536	0,072	-0,177	0,289
Mental Rotation (Figures found, corrected f. guess.)	0,497	0,406	0,074	0,391	-0,013	-0,278	0,116
Tapping (Left hand)	0,312	0,252	0,024	0,672	0,064	-0,033	-0,124
Tapping (Right hand)	0,311	0,121	-0,029	0,737	0,005	0,133	-0,148
Oral fluency	0,419	0,010	0,120	0,586	0,165	0,176	0,040
WISC Information	0,529	0,333	0,578	0,011	0,090	-0,061	0,079
WISC Comprehension	0,469	0,293	0,572	0,141	0,044	0,078	-0,073
WISC Arithmetic	0,533	0,075	0,279	-0,196	0,072	-0,100	0,436
WISC Similarities	0,463	0,258	0,663	0,001	0,054	0,113	-0,050
WISC Vocabulary	0,492	0,321	0,654	-0,138	0,043	-0,024	0,053
WISC Digit Span	0,524	-0,117	0,127	-0,068	0,018	0,083	0,448
WISC Picture Completion	0,193	0,451	-0,005	-0,167	-0,329	-0,397	0,039
WISC Picture Arrangement	0,290	0,325	0,314	-0,132	-0,181	-0,110	-0,023
WISC Block Design	0,593	0,286	0,097	0,059	-0,250	-0,158	0,257
WISC Object Assembly	0,454	0,210	0,080	-0,219	-0,572	0,004	0,126
WISC Coding	0,477	-0,276	-0,097	0,268	-0,111	0,327	0,302
Point-biserial factor loading of sex	**0,009**	**0,518**	**0,082**	**0,065**	**0,178**	**-0,571**	**-0,035**

Loading > 0,300 are italized

Figure 8.

Factor loadings for 52 16+ year boys and girls on hierarchical orthogonal components (Schmid-Leiman) for 21 variables, with eigenvalues > 1. Point-biserial correlations (adjusted for inequal Ns and SDs), were factored in to indicate loading of sex on each of the dimension

	g	Verbal	Spatial Orientation	Visualization and Dexterity	Mental Rotation	Short-term Memory	Quant-itative ability
	Secondary 1	Primary 1	Primary 2	Primary 3	Primary 4	Primary 5	Primary 6
RFT Frame dependence (signed error, inv.)	0,423	-0,032	0,812	-0,128	0,072	0,062	-0,054
RFT Response variability (error, inv.)	0,424	-0,152	0,622	0,192	0,029	0,169	0,041
RFT Field dependence (unsigned error, inv.)	0,434	0,006	0,830	-0,076	0,016	0,024	-0,093
Embedded-Figures test (sec/fig inv.)	0,466	0,155	-0,081	0,301	-0,248	0,017	0,275
Money left-right discrimination test (Inv.)	0,630	-0,173	0,094	0,310	0,268	-0,027	0,426
Mental Rotation (Figures found, corrected f. guess.)	0,501	0,245	0,150	0,129	0,420	-0,243	0,029
Tapping (Left hand)	0,241	0,100	0,002	0,798	0,023	-0,049	-0,159
Tapping (Right hand)	0,283	-0,005	-0,075	0,708	-0,191	0,072	0,072
Oral fluency	0,182	0,444	0,108	0,187	-0,562	0,256	-0,132
WAIS Information	0,545	0,626	-0,026	0,147	-0,054	-0,053	0,024
WAIS Comprehension	0,387	0,409	-0,154	-0,074	-0,321	0,271	0,270
WAIS Arithmetic	0,469	0,212	-0,221	-0,167	0,089	0,391	0,485
WAIS Similarities	0,451	0,748	0,049	0,075	-0,035	0,041	-0,142
WAIS Digit Span	0,163	0,044	0,202	-0,035	0,113	0,757	0,088
WAIS Vocabulary	0,487	0,662	-0,144	-0,060	0,152	-0,065	0,059
WAIS Digit Symbol	0,025	-0,019	-0,076	0,222	-0,639	-0,220	0,074
WAIS Picture Completion	0,407	0,103	0,253	0,270	0,051	-0,048	0,017
WAIS Block Design	0,668	0,060	0,204	-0,117	-0,150	-0,099	0,457
WAIS Picture Arrangement	0,451	0,165	0,090	-0,067	0,038	-0,565	0,163
WAIS Object Assembly	0,535	-0,094	0,307	-0,067	-0,314	-0,127	0,389
Point-biserial factor loading of sex	0,272	0,117	0,165	0,431	0,589	0,052	-0,187

Loading > 0,300 are italized

Figure 9.

Comparison of childhood and adult factor loadings on sex (Point-biserial correlation)

Dimension	g	Mental Rotation	Verbal	Visualization and Dexterity	Spatial Orientation	Quant-itative ability	Speed and Accuracy	Short-term Memory
Level	Second.	Prim./Sec.	Primary	Primary	Primary	Primary	Primary	Primary
Young Rpbs factor loading of sex	0,009	0,518	0,082	0,065	0,178			-0,035
Adult Rpbs factor loading of sex	0,272	0,589	0,117	0,431	0,165	-0,187	-0,57	0,052