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Sex differences in brain size, stature and intelligence in children and adolescents: some evidence from Estonia

Richard Lynn[a,*], Juri Allik[b], Olev Must[b]

[a]*University of Ulster, Coleraine, Northern Ireland, UK*
[b]*University of Tartu, Tartu, Estonia*

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Abstract

Sex differences in brain size and stature decrease from the age of 7 through 13–14 years and increase from the age of 15 through 18 years in Estonia, as they do in the United States. Sex differences in intelligence show a somewhat similar decrease and increase although they do not move precisely in synchrony with the morphological trends. The results are interpreted as suggesting that sex differences in maturation determine the magnitude of sex differences in physical and mental development during childhood and adolescence. © 2000 Elsevier Science Ltd. All rights reserved.

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1. Introduction

Students of the issue of sex differences in intelligence have almost invariably concluded that while there are differences in some specific or primary abilities, differences in "general intelligence" are negligible. For example, in 1971 Cattell wrote that "it is now demonstrated by countless and large sample researches that on the two main general cognitive capacities — fluid and crystallised intelligence — men and women, boys and girls show no significant differences" (Cattell, 1971, p. 131). More recently it has been written that "gender differences in general intellectual ability are small and virtually nonexistent" (Brody, 1992, p. 323); "there is no sex

* Corresponding author. Whitfield Court, Glewstone, Ross-on-Wye, Hertfordshire HR9 6AS, UK. Tel.: +44-1265-44141.

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difference in general intelligence worth speaking of'' (Mackintosh, 1996); ''gender differences tend to approach zero if researchers employ general or relatively unselected samples'' (Richardson, 1997); ''the sex difference in psychometric *g* is either totally nonexistent or is of uncertain direction and of inconsequential magnitude'' (Jensen, 1998, p. 540).

This unanimous conclusion has been challenged by Lynn (1994, 1996, 1998) who advances the following propositions: (1) the issue of sex differences in intelligence needs to be analysed developmentally because girls mature faster than boys over the age range 8–15 years; from the age of 8 years the growth rate of girls begins to accelerate, in relation to that of boys, so that girls are on average taller and heavier than boys between the ages of 8–15; from the age of 16 years onwards, the growth rate of girls slows relative to boys, with the result that boys become taller and heavier than girls; (2) these maturational sex differences in height and weight are also present in head size, which is itself an approximate measure of brain size; the brain size of girls increases relative to that of boys from the age of 8 years up to the ages of 13–14 years, after which it begins to decrease progressively up to the age of 18 years and possibly beyond; however, unlike height and weight, the head size/brain size of girls does not become absolutely larger than that of boys over the 8–15 year age range, but only becomes relatively larger; (3) sex differences in intelligence follow the same developmental sequence as those in height, weight and brain size, i.e. they move in favour of girls over the age range 8–15 years, but from 16 years onwards they move in favour of boys; (4) thus, sex differences in intelligence are small over the age range 8–15 years, but they begin to increase progressively in favour of males from the age of 16 years onwards until among adults they become appreciable, ranging between 2–11 IQ points in different samples reviewed in Lynn (1994, 1996, 1998) and Allik, Must and Lynn (1999); (5) the developmental trends in sex differences in brain size and intelligence move in parallel because brain size is a determinant of intelligence, the evidence for which is reviewed by Rushton (1995).

In this paper we examine this theory further in a report of data from Estonia for sex differences in intelligence, head size and stature among children and adolescents.

2. Method

2.1. Intelligence test data

The intelligence data to be presented were collected in Estonia by the late Juhan Tork in 1933–1934 and published in Estonian in 1940 (Tork, 1940). The study has never entered the world literature on intelligence because shortly after it was published the Russians occupied Estonia, prohibited academic work on intelligence in conformity with prevailing policy throughout the Soviet Union and removed from circulation most copies of the book. A few copies survived but because the book was proscribed it was never translated into English or any other major language and consequently has remained unknown to the international community.

Tork's study consisted of a collection of data for intelligence from a representative sample of 3019 school children aged 9–15 years, with approximately equal numbers of boys and girls. The test was an Estonian adaptation of the American *National Intelligence Test* developed by

Haggerty, Terman, Thorndike, Whipple and Yerkes (1919). It is a group test of verbal reasoning and verbal comprehension containing problems in arithmetic, sentence completion, logical inference, synonyms–antonyms, information, vocabulary, analogies and comparisons. The means of the boys and girls for each year of age, the *d*'s (the sex differences divided by the pooled standard deviation) and the *t* values for the sex differences are presented in Table 1. The broad pattern of the results is that at age 9 there is no statistically significant sex difference; at age 10 girls obtain a significantly higher mean IQ than boys; from age 11 through 15 boys obtain higher mean IQs than girls; and these differences are statistically significant except at age 12.

2.2. Anthropometric data

The anthropometric data were collected on Estonian school children and adolescents in the early 1950s by the late Juhan Aul (1977), professor of anthropology at the University of Tartu. The data consist of measures of head width (frontal) and head length (saggital) and also of stature. We have calculated cranial capacities in cubic centimetres from the head width and head length data, using the formula proposed by Lee and Pearson (1901) as modified by Rushton (1995) who subtracts 11 mm from the width and length to allow for fat and skin around the skull. For males this formula is: $cc = 6.752\,(L - 11\text{ mm}) + 11.421\,(B - 11\text{ mm}) - 1434.06$; for females: $cc = 7.884\,(L - 11\text{ mm}) + 10.842\,(B - 11\text{ mm}) - 1593.96$. These data are presented in Table 2. With regard to stature, it will be noted that boys are taller than girls from the ages of 7–10 years; from the age of 12 through 13 girls are taller than boys; from the age of 15 onwards, boys are again taller than girls. With regard to head size, it will be noted that boys have larger heads throughout the age range but the difference narrows from 123.80 cc at age 7 to 109.09 cc at age 13, and then widens to 159.67 cc at age 18.

The most useful way of treating the data is to consider the stature and head size of females over the age range as percentages of those of males. These results are shown in Table 3 together with, for comparison, the corresponding American data given by Lynn (1994). It will be noted that the two sets of data show a close similarity. In regard to stature, the girls grow

Table 1
Means for boys and girls on intelligence

Age (years)	Boys			Girls			*d*	*t*[a]
	N	mean	S.D.	*N*	mean	S.D.		
9	95	130.9	44.2	68	121.2	44.8	0.22	1.37
10	252	138.5	48.3	186	153.7	45.6	0.32	3.32**
11	235	175.7	59.1	255	161.7	49.0	0.26	2.84**
12	319	200.0	55.3	368	195.1	55.1	0.09	1.16
13	289	228.0	58.6	337	217.8	56.8	0.18	2.20*
14	177	234.3	54.9	211	221.6	54.6	0.23	2.28*
15	108	236.3	45.8	119	218.8	48.9	0.37	2.78**

[a] Statistical significance at the $^{*}p = 0.05$ and $^{**}p = 0.01$..

Table 2
Means for boys and girls on head length and width (mm), brain volume (cc) and stature (mm)

Age (years)	Number		Head length		Head width		Brain volume		Stature	
	boys	girls	boys	girls	boys	girls	boys	girls	boys	girls
7	623	626	179.35	175.29	149.10	145.18	1279.88	1156.08	121.85	120.80
8	1215	1205	180.18	176.10	149.71	145.65	1290.45	1167.56	126.74	125.74
9	1355	1300	181.09	176.97	150.41	146.30	1306.45	1181.47	131.05	130.64
10	1402	1373	182.09	177.89	151.00	146.79	1320.08	1194.04	136.55	135.70
11	1466	1419	183.02	179.20	151.63	147.50	1333.55	1212.06	141.36	141.37
12	1538	1544	184.05	180.60	152.30	148.48	1348.16	1238.72	146.22	147.46
13	1517	1517	185.19	181.94	152.97	149.42	1363.57	1254.48	151.41	152.72
14	1500	1476	186.60	182.90	153.72	150.08	1381.60	1269.20	157.30	157.30
15	1387	1465	188.20	183.64	154.63	151.03	1402.79	1285.34	163.90	159.90
16	1213	1276	189.61	184.18	155.44	151.56	1421.56	1295.34	168.87	161.17
17	970	1091	191.22	184.64	156.28	151.82	1442.03	1301.79	172.20	162.20
18	666	903	192.80	184.80	157.11	151.77	1462.18	1302.51	174.10	162.53

more rapidly than boys from the age of 8 years; the female advantage peaks at ages 13–14 in both data sets and then declines; boys become increasingly taller than girls from the age of 15 onwards. The correlation between the two sets of figures is 0.94 ($p < 0.001$). In regard to head size, the differences between boys and girls decline steadily from the age of 7 to 13/14, after which they increase again up to age 18. The correlation between the two data sets is 0.93 ($p < 0.001$)

Table 3
Brain size and stature of girls as percentage of boys in Estonia and the United States

Age (years)	Brain size		Stature	
	Estonia	United States	Estonia	United States
7	90.33	90.2	99.1	98.5
8	90.48	90.6	99.2	101.1
9	90.42	90.6	99.7	101.0
10	90.45	90.4	99.4	101.7
11	90.89	91.4	100.0	100.3
12	91.51	92.2	100.8	101.3
13	92.00	92.5	100.9	101.3
14	91.86	92.6	100.0	102.0
15	91.63	91.5	97.6	99.3
16	91.12	91.2	95.4	97.1
17	90.27	89.2	94.2	93.6
18	89.08		93.4	92.9

3. Discussion

The results contain three principal points of interest. First, they provide confirmation that girls mature faster than boys over the age range of 7/8 years to around 15 years. This appears in the Estonian data for both stature and head size, for which the sex differences decrease over this age range in a manner closely similar to that in the United States.

Secondly, the sex differences in intelligence also show some narrowing and subsequent broadening over the same age range. A small and nonsignificant difference at age 9 is followed by a significant difference in favor of girls at age 10, which is in turn followed by differences in favor of boys from the age of 11 through 15. The results confirm in general terms the thesis that the analysis of sex differences in intelligence requires close attention to age differences. Thus in these data the statement that "there are no sex differences in intelligence" is true for age 9 but untrue for ages 10 and 11.

Thirdly, although the sex differences in brain size and stature and for intelligence show the same general trend of a narrowing and subsequent broadening over the age range 9–15 years, they do not move in perfect synchrony. The girls' advantage in intelligence peaks at the age of 10, while their advantage for stature peaks at the age of 13 and their disadvantage in respect of brain size is smallest at the age of 13. Possibly the explanation for this lack of synchrony is that the "growth spurt" of girls which begins to occur at the age of 7/8 years has different trajectories for different morphological and physiological characteristics. For example, the myelinisation of the brain neurones increases during childhood and adolescence and is positively related to intelligence (Miller, 1994). It is possible that this or some similar process may occur more rapidly in girls and match more precisely the accelerated development of girls' intelligence around the age of 10 years.

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