EDITORIAL

Sex Differences in Intelligence and Brain Size: A Developmental Theory

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In 1992, it was reported by Ankney and Rushton that males have larger average brain size than females even when allowance is made for body size. It is known that brain size is associated with intelligence, and it would therefore be expected that males would have higher intelligence than females. Yet it has been universally maintained that there is no difference in intelligence between the sexes. It is proposed that this anomaly can be resolved by a developmental theory of sex differences in intelligence which states that girls mature more rapidly in brain size and neurological development than boys up to the age of 15 years. The faster maturation of girls up to this age compensates for their smaller brain size with the result that sex differences in intelligence are very small, except for some of the spatial abilities. From the age of 16 years onwards, the growth rate of girls decelerates relative to that of boys. The effect of this is that a discernible male advantage of about 4 IQ points develops from the age of 16 into adulthood, consistent with the larger average male brain size. This paper presents new evidence on the developmental theory of sex differences in intelligence and discusses alternative attempts to deal with the anomaly by Ankney (1995), Mackintosh (1996), and Jensen (1998).

It is a principle of scientific thinking that special attention is required when an anomaly is found in an established theory. An anomaly tells us that something is wrong with the theory and that the theory needs to be modified. In 1992, just such a troublesome anomaly surfaced in the field of sex differences in intelligence when it was reported by Ankney (1992) and Rushton (1992) that males have larger brains than females, even when allowance is made for differences in body size. Hitherto, it had been believed that "relative to body size, there are no sex differences in brain weight" (Halpern, 1992, p. 140). The "Ankney–Rushton anomaly" is that it is well-established that brain size is positively associated with intelligence. Therefore, as males have larger average brain size than females, they should have a higher average intelligence. Yet, it had been universally

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maintained for many decades that there is no difference in intelligence between males and females. For instance, "it is now demonstrated by countless and large sample researches that on the two main general cognitive capacities — fluid and crystallized intelligence — men and women, boys and girls, show no significant differences" (Cattell, 1971, p. 131) and "gender differences in general intellectual ability are small and virtually non-existent" (Brody, 1972, p. 323).

In this paper, I consider four attempts to solve the Ankney–Rushton anomaly. These are: (1) my own theory that general intelligence should be defined as consisting of the sum of the verbal comprehension, reasoning and spatial group factors, and that if it is so defined, males have an intelligence advantage among adults of approximately 4 IQ points, consistent with their larger brain size, although this advantage is less clearly discernible among children; (2) the alternative attempts to resolve the anomaly proposed by Ankney (1992; 1995), Mackintosh (1996) and Jensen (1998).

The Developmental Theory

My developmental theory of sex differences in intelligence consisted of five propositions. (1) We need to begin by defining intelligence. I proposed that general intelligence should be defined as the sum of the verbal comprehension, reasoning and spatial abilities. This definition is based on the hierarchical model of intelligence proposed by Gustafsson (1984), of which Bouchard (1993, p. 34) has written that it "probably incorporates the consensus more than any other" and further evidence for which has been provided by Carroll (1993). (2) We need next to fit data to the model. This should be done in the first instance for adults because the faster maturation of girls up to the age of 16 counteracts the advantage gained by males from their larger brain size. Fitting American data for adults to the model, it was proposed that males have higher mean IQs than females of 1.7 IQ points for verbal comprehension, 2.1 IQ points for reasoning (the average of 1.8 for verbal reasoning and 2.4 for non-verbal reasoning) and 7.5 IQ points for spatial ability. These scores can be averaged to a 3.8 IQ point male advantage for general intelligence, which can be rounded to 4 IQ points. Similar data were presented for Britain, Norway, Sweden, Indonesia and Northern Ireland, all of which showed a male advantage of similar magnitude. In addition, six data sets of the Wechsler adult intelligence test were assembled, four of which were from the US and one each from The Netherlands and China, in all of which males obtained higher mean full scale IQs than females ranging between 1 and 5 IQ points and averaging 3.1 IQ points. The Wechsler full scale IQ is proposed as an approximate alternative measure of general intelligence defined as the sum of verbal comprehension, reasoning and spatial abilities. Thus, we have in all 12 data sets all showing higher mean IQs in males among adults. (3) The adult male advantage of around 4 IQ points obtained by averaging the verbal comprehension, reasoning and spatial abilities is not generally found in the full scale IQ of the Wechsler tests or in the overall IQ of similar tests because the spatial abilities are typically under-represented in these tests. (4) The male advantage of around 4 IQ points among adults can be predicted from the larger average male brain size as follows: the male–female difference in brain size in SD units is 0.78d; this should be multiplied by 0.35 (the correlation between brain size and IQ) = 0.27d = 4.05 IQ points. (5) The male advantage in both brain size and intelligence is less in children and young adolescents because girls mature more rapidly than boys in general and in brain size in particular, especially over the age range of 8 through 15-years old. The male advantage in both brain size and intelligence increases from the age of 16 years onwards as the growth rate of the female brain slackens relative to that of the male. The ratio of female:male brain size fluctuates by age. Thus, the cranial capacity of the female brain is 93.2% that of the male at age 4 months (Rushton, 1997), 89.6% of the male at age 5 years, increases gradually to 92.6% of the male at age 14 years and then declines steadily to 86.6% of the male among young adults in their mid-20s. Recent confirmation of these figures has been presented by Rushton (1997). The developmental theory of sex differences in intelligence predicts that (a) in general, sex differences will be relatively small among children and young adolescents up to the age of 15, will begin to increase from age 16 onwards and will reach their maximum among adults; evidence supporting this proposition is presented in the work of Lynn (1994) in which it was shown, for example, that the male advantage on eight standardisation samples of the WISC averaged 2.35 IQ points, a little less than on six samples of the WAIS; (b) sex differences in intelligence should run in synchrony, year by year, with the differences in brain size; the details of this prediction have yet to be worked out. Because sex differences in intelligence should appear most clearly among adults, when the maturational processes are completed, the first priority of the developmental theory is to establish the adult male advantage and this is the principal objective of the present paper.

New Data on Sex Differences

Before turning to the alternatives to this theory proposed by Ankney, Mackintosh and Jensen, it will be useful to widen the data base from which these issues can be considered. To do this, 20 further data sets on sex differences among those aged 16-years-old and older are presented in Table 1. The numbers in the table represent sex differences in IQs with positive signs representing higher mean IQs in males and negative signs higher mean IQs in females. The figures for general IQ represent the full scale or global IQs of tests like the Wechsler's, Kaufman's, etc., or the sum of verbal comprehension, general reasoning and spatial abilities. The figures for general reasoning are the average of verbal and abstract reasoning or of verbal and quantitative reasoning in the case of the Kaufman et al. (1995) study, or the single estimate given by Jackson and Stumpf (1994). The penultimate row gives the averages of the figures and the bottom row gives the estimates I made in my 1994 paper. It will be noted that the new data correspond very closely with the 1994 estimates for general intelligence, the performance IQ of the Wechsler, verbal reasoning and spatial ability. The new data give rather greater male advantages for general reasoning and abstract reasoning abilities.

It will be observed that 15 of the data sets consist of general population samples whereas five of the data sets (numbered 10, 11, 14, 15 and 16) consist of restricted samples of university students (11), applicants for universities (10, 14, 16) or for pilot training (15). The restricted samples can be assumed to have higher than average intelligence. It has sometimes been argued that males have greater variability for intelligence than females. If this is so, males will have higher mean IQs than females in samples drawn predominantly from the top half of the intelligence distribution and lower IQs than females in samples

Table 1. Sex Differences in General Intelligence and Various Abilities

Study	*Location*	*Number*	*Test*	*General IQ*	*Verbal IQ*	*Performance IQ*	*General Reason*	*Verbal Reason*	*Abstract Reason*	*Quantitative Reason*	*Spatial IQ*
1	Portugal	6280	DRTB				4.4*	2.7*	6.1*	9.9*	8.6*
2	Japan	1402	WAIS-R	3.3*	4.2*	1.5*					
3	Scotland	200	WAIS-R	5.1*	5.4*	3.7*					
4	USA	230	WAIS-R	3.4*	3.1	3.0					
5	USA	2022	K-BIT	2.2*	2.6*				1.4		
6	USA	1146	K-AIT	3.3*	1.2		2.3*	1.0		3.7*	7.2*
7	SA — Blacks	1093	JAT	5.2*	1.0		4.7*	3.4*	6.0*		10.0*
8	SA — Indians	1062	JAT	3.9*	−3.4*		4.2*	1.6	6.9*		11.1*
9	SA — Whites	1056	JAT	4.3*	0.6		4.8*	1.5	8.4*		7.5*
10	Estonia	1201	TIT	6.6*	2.2*		11.4*				6.3*
11	Germany	187110	TMS				8.4*				
12	Greece	1176	AH4				4.2*	1.8*	6.7*		
13	Ireland	2600	DAT	2.6*	0.1		3.7*	3.7*	3.7*		4.0*
14	Israel	1778	SATB		2.7*		2.1*	−0.3	2.4*	7.5*	
15	USA	269968	AFOQT	3.9*	1.3*		3.4*	0.3	6.6*		7.4*
16	USA	46379	SAT		1.8*					6.3*	
17	Israel	30000	IMT						1.7*		
18	England	666	RPM						5.6*		
19	Hawaii	2353	RPM						3.8*		
20	Belgium	2104	RPM						6.4*		
	Means			3.6	1.8	2.7	4.9	1.7	5.0	6.0	7.8
	Previous means (Lynn, 1994)			3.8	1.7	1.8	2.1	1.8	2.4		7.5

Note: Positive numbers denote higher scores for males, negative signs higher scores for females. Notes on studies: (1) Standardisation sample aged 16–18 of the Differential Reasoning Tests Battery (Almeida, 1989); (2) Japanese standardisation sample aged 16–74 (Hattori & Lynn, 1997); (3) Scottish standardisation sample aged 16–74 (Lynn, 1998); (4) general population sample aged 16–71 (Arceneaux, Cheramie, & Smith, 1996); (5) standardisation sample aged 4–90 (Kaufman & Wang, 1992); (6) standardisation sample of K-AIT(Kaufman, Chen, & Kaufman, 1995); (7, 8 and 9) general population samples aged 16 (Owen & Lynn, 1993); (10) applicants to the University of Tartu aged 19 on the Tartu Intelligence Test (Allik, Must, & Lynn, 1999); (11) medical students aged 18–29 (Jackson & Stumpf, 1994); (12) school students aged 16–18 (Alexopoulos, 1996); (13) school students aged 18 (Lynn, 1996); (14) college applicants aged 24 (Zeidner, 1986); (15) applicants for pilot training aged 21 (Carretta, 1997); (16) college applicants aged 17–18 (Ramist, Lewis, & McCamley-Jenkins, 1994); (17) Israeli military conscripts aged 17 on the Israel Matrices Test (Flynn, 1998); (18) general population sample aged 20–79 on Raven's Progressive Matrices (Heron & Crown, 1967); (19) general population sample aged 18–55 on Raven's Progressive Matrices (Wilson et al., 1975); (20) general population sample aged 20–80 on Raven's Progressive Matrices (Deltour, 1993).

*Statistically significant differences.

drawn predominantly from the lower half. This would make the five restricted sample studies inappropriate for estimating sex differences in intelligence in the general population. However, Feingold (1992) in an extensive study of this issue concludes that males do not have greater variability than females with respect to the abilities shown in the table, except perhaps in the spatial abilities. Furthermore, the male advantage in the five restricted samples differs little from their advantage in the general population samples and so no distinction will be made between the two kinds of data in subsequent discussion.

Ankney's Theory

When Ankney (1992) reported that males have greater average brain size than females, he adopted the commonly held position that the higher spatial and mathematical abilities of males are counterbalanced by the higher verbal abilities of females. To resolve the anomaly of the apparent absence of any sex difference in general intelligence, conceptualized as the sum of spatial and verbal abilities, Ankney proposed that the spatial and mathematical abilities might require more brain tissue than the verbal abilities. In a subsequent discussion of the anomaly, Ankney (1995) modified this view and contended that (1) the sex differences in verbal abilities are negligible; (2) males have higher spatial and mathematical reasoning abilities; (3) if all these abilities are summed to produce general intelligence, males have higher average general intelligence than females, consistent with their higher average brain size. This solution to the anomaly is very close to my own and the data set out in Table 1, together with the data presented in my 1994 paper, show that what Ankney says is broadly correct. I differ from Ankney in that: (1) I contend that males have a small advantage over females in verbal ability, as shown in Table 1, which contributes to their advantage in general intelligence; (2) I contend that males have a significant advantage in abstract reasoning ability; and (3) I would regard mathematical ability as a function of general reasoning and spatial abilities (notice that in the data set out in Table 1 the male advantage in mathematical/quantitative ability is very close to the average of the general reasoning and spatial abilities).

Mackintosh's Theory

Mackintosh (1996, 1998) disagrees fundamentally with my theory and has presented an extensive critique of it. He advances three principal points. (1) He agrees that males have larger average brain size than females and that brain size is positively associated with intelligence but he disputes that this implies that males should have higher average IQs than females. He argues that birds have larger brain size relative to body size than fish, yet they may not be more intelligent. He says that birds were unable to evolve larger body size because this would have prevented them from flying; fish, on the other hand, were able to evolve larger bodies because they did not attempt to fly. So, he concludes, "the difference in ratio of brain to body may reflect a difference in bodies, not in brains. The same argument must apply to comparison of the sexes in a sexually dimorphic species such as *Homo sapiens*" (p. 566). I suspect that most readers will find this argument as impenetrable as I do and will not be persuaded that Mackintosh has succeeded in spiriting away the problem that males have larger brains than females and yet have been regarded as no more intelligent. (2) Mackintosh agrees that if intelligence is defined as the sum of verbal comprehension, reasoning and spatial abilities, then males have higher average intelligence than females because no matter what fine tuning might be applied to my quantification of the male advantage on the three abilities, the male advantage on the spatial abilities is sufficiently great to give males higher general intelligence. (3) However, he does not accept this definition of intelligence. Instead, he proposes that general intelligence should be defined as fluid or reasoning ability and that the best measure of this is the Progressive Matrices. He states that there is no sex difference on the Progressive Matrices, and therefore, there is no sex difference in general intelligence. In support of his contention that there is no sex difference on the Progressive Matrices he cites a review by Court (1983), a study of deaf 15-year-olds by Conrad (1979) and data from an unpublished study of military conscripts in Israel provided by James Flynn.

There are four weaknesses in Mackintosh's position. (1) Few people will be persuaded that general intelligence can be so narrowly defined as to consist solely of fluid ability measured by the Progressive Matrices. General intelligence is generally regarded as consisting of a broader range of cognitive abilities which would include the verbal and spatial second order factors. Thus, 52 leading psychologists in a letter to the *Wall Street Journal* in 1994 defined intelligence as "a very general mental capacity which, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience" (Gottfredson, 1997, p. 13); others have defined intelligence as "the sum total of all cognitive abilities" (Stankov & Roberts, 1997, p. 76) and "the acquired repertoire of all intellectual (cognitive) skills and knowledge available to a person at a particular point in time" (Humphreys, 1994, p. 180). It is evident that Mackintosh's proposal that general intelligence should be defined as reasoning or fluid ability commands little assent. (2) Mackintosh does not acknowledge the sex differences in maturation component of the developmental theory. He uses combined results from children and adults to support his case that there is no sex difference on the Progressive Matrices. The results of Conrad, which he singles out for citation in support of his position, are for 15-year-olds so they have little relevance for the theory that the male advantage in reasoning begins to appear at around the age of 16 and, furthermore, show a 3 IQ point advantage for males. Most of the studies reviewed by Court are on children and young adolescents and hence do not bear on the developmental theory that sex differences in intelligence are minimal up to the age of 15 and only begin to emerge clearly from the age of 16. His contention that sex differences on the Progressive Matrices are negligible among children up to the age of 15 is correct (Raven, 1981), but among adults males have an advantage on this test. Only three such studies have been published on appreciable sample sizes of over 500, and the results of these are given as the last three studies in Table 1. In all three studies, males obtain significantly higher means than females. Mackintosh (1998) says there are other studies of adults in Court's review which show a female advantage but these are not studies of representative samples of the general population but of psychiatric patients which Court warns are unrepresentative. (3) Mackintosh's assertion that Flynn's Israeli data show no sex difference on the Progressive Matrices is incorrect. At the time Mackintosh made this claim, the data had not been published and so readers had to take the assertion on trust. Now that Flynn (1998) has published the data, it appears that the test used was not the Progressive Matrices but some other kind of non-verbal reasoning test, that only 70% of females were conscripted and tested and the conscripted females were of above-average intelligence. The sample is clearly not representative for females. Flynn has made some assumptions to adjust for the deficiencies of the sample and on the basis of these estimates that the mean IQ of Israeli 17-year-old females is 1.4, 1.7 or 2.0 IQ points (depending on different assumptions) below that of males on this test (the mean/median of these estimates is entered in Table 1). Thus, contrary to Mackintosh's contention, this result supports the developmental theory that among older teenagers, males have an advantage in abstract reasoning ability. (4) Mackintosh's contention that there is no sex difference on reasoning ability is further disconfirmed by the 11 additional data sets in Table 1 all of which show that males have higher general, verbal, abstract and quantitative reasoning ability than females.

Jensen's Theory

The approach of Jensen (1998) to the Ankney–Rushton anomaly has three points of similarity to that of Mackintosh and two main differences. The points of similarity are as follows. First, he argues (like Mackintosh) that the larger average male brain does not necessarily imply that males must have higher average IQs than females. He suggests that "the sex difference in brain size may be best explained in terms of the greater 'packing density' of neurons in the female brain, a sexual dimorphism that allows the same number of neurons in the male and female brains despite their difference in gross size" (p. 541).

This thesis is improbable on both theoretical and empirical grounds. Theoretically, a large brain entails a servicing cost and it would be more efficient to have a small brain which did the job just as effectively. If a more efficient adaptation of this kind had evolved in females, it is inconceivable that it would not also have evolved in males. This point was made by Ankney (1992, p. 335) when he considered possible resolutions of the problem that males have larger brains than females but are apparently no more intelligent. Perhaps, he wrote, "women's brains are more efficient than those of men" but "as an adaptationist, I discount this." Jensen's thesis that the female brain contains more densely packed but the same average number of neurons as the male brain also encounters empirical difficulties. In support of this thesis, he cites a study by Witelson, Glezer and Kigar (1995) of five female and four male brains in which the neurons were more densely packed in the posterior temporal cortex of the female brains. However, Packenberg and Gundersen (1997) compared 62 male and 32 female brains and estimated the numbers of neurons in the entire cerebral cortex. They report that the average male brain contained 22.8 billion neurons and the average female brain 19.3 billion, a statistically significant difference, but there was no sex difference in neuronal density. The average number of female neurons in this study is 85% that of males. This is almost identical to the sex difference in cranial capacity estimated by Rushton (1992), in which average female cranial capacity is 86% of that of males. From this, we can conclude that estimates of male and female cranial capacity provide an accurate estimate of the numbers of neurons in the average male and female brain.

Secondly, Jensen (like Mackintosh) argues that Spearman's *g* can be identified with fluid ability and measured by the Progressive Matrices, that Court (1983) showed that there is no difference between males and females on the Progressive Matrices, and hence, that there is no sex difference in fluid ability and *g*. Thirdly, Jensen (like Mackintosh) declines to acknowledge that there are sex differences in the rate of maturation of intelligence and hence, fails to note that although sex differences on the Progressive Matricess are negligible up to the age of 16 as shown by Raven (1981) in the standardisation sample of the test, among adults, males have higher mean scores on the Progressive Matrices than females, as shown in Table 1.

There are two principal points of disagreement between Jensen and Mackintosh. First, Jensen believes that for practical purposes, Spearman's *g* can be measured by the full scale IQ of the Wechsler test and the total scores of similar tests. The full scale IQ of the Wechsler tests can be used as a measure of *g* because "the *g* factor scores obtained from the whole Wechsler battery are correlated more than 0.95 with the tests' total scores" and "with such a high correlation between factor scores and IQ scores, it is pointless to calculate factor scores" (p. 90). Almost as good measures of *g* are obtained from the overall scores on aptitude tests like the GATB, the ASVAB and the SAT because these are "nearly as highly *g* loaded as IQ tests" (p. 91). Mackintosh does not agree that the full scale IQs of the Wechsler test and the overall scores of similar tests provide acceptable measures of *g*. Jensen is right that the global IQ or score of most of these tests provide a good approximate measure of general intelligence, whether this is defined as the sum of verbal, reasoning and spatial abilities or as the first principal component, but Mackintosh has adopted the better debating position because if it is conceded that the global IQs and scores derived from these tests are measures of *g*, then the large body of evidence summarized in Table 1 and in the work of Lynn (1994) shows that among adults, males obtain higher means than females on all these tests which leads to the conclusion that among adults, males have higher average *g*.

The second point on which Jensen and Mackintosh differ is that Jensen contends that *g* can be identified as the first principal component obtained by factor analysis of a test battery containing a number of diverse cognitive tests and that virtually the same *g* appears from different test batteries. According to Jensen, "*g* remains quite invariant across many different collections of tests" (1998, p. 85). Mackintosh disagrees and contends that "contrary to the oft-repeated, but rarely documented, claim of many IQ testers that the general factor extracted from one test battery is essentially the same as the general factor extracted from another, research on sex differences suggests that different batteries yield significantly different general factors" (1996, p. 567). To substantiate this point, Mackintosh observes that on the *g* derived from the Wechsler tests, males typically outperform females by around 4 IQ points, but on the *g* obtained from the Differential Aptitude Test, females outperform males. Hence, he concludes, in my opinion correctly, that for the analysis of sex differences in *g* "little will be gained by further pursuit of the precise nature of general intelligence defined in this way" (p. 567).

Jensen, however, believes that the definitive method for determining the issue of sex differences in *g* is to define *g* as the first principal component and calculate sex differences on this. He analyzes five tests by this method. His results (1998, p. 539) are that there is a male advantage of 5.49 IQ points on the ASVAB (Armed Services Vocational Aptitude Battery), of 2.83 IQ points on the WISC-R, and of 0.18 IQ points on the WAIS; and a female advantage of 0.03 on the BAS (British Ability Scales) and of 7.91 IQ points on the GATB (General Aptitude Test Battery). From these results, he concludes that "the sex difference in psychometric *g* is either totally non-existent or is of uncertain direction and of inconsequential magnitude" (p. 540).

This conclusion is open to two general criticisms. (1) The five data sets are not well-selected to test the developmental theory of sex differences. Two of the five are for children and young adolescents (the WISC-R for 6–16-year-olds and the BAS for 14–16-year-olds) and therefore, do not provide a proper test of the developmental theory that sex differences only emerge clearly from the age of 16 years. (2) The three data sets for adults produce disconcertingly inconsistent results. With such a great disparity of estimates, Jensen's solution of averaging them and concluding that there is no sex difference cannot be regarded as satisfactory. At least one of the studies must be seriously flawed and the proper approach is to try to discover where the flaws lie. Three flaws in the studies can be identified. (1) The *g* values extracted from different test batteries are not nearly so consistent as Jensen contends. The reason for this is that the nature of the *g* depends on the kind of tests in the battery from which it is extracted. The Wechsler batteries consist of six verbal tests and a miscellany of spatial, perceptual speed, visual and non-verbal reasoning tests, so it yields a verbal *g*. Because females perform relatively well on verbal tests, Wechsler *g* values are biased in favor of females. This is one reason why the male advantage on the *g* extracted by Jensen from the WAIS is so small. A second reason is that of the nine samples giving sex differences on the WAIS summarized in the work of Lynn (1994) and Table 1, Jensen has opted to analyze the one with the smallest male advantage. A third reason is that Jensen has opted to extract for analysis from the WAIS standardisation sample only the 25–34-year age group, in which the male advantage is smaller than on the total sample. (2) The ASVAB consists of a reasonably well-balanced variety of 10 tests of verbal, arithmetical, mathematical, reasoning, perceptual speed and scientific abilities. It does not contain a spatial test, so this handicaps males, but it contains three science/mechanics/electronics tests which handicap females, so the net result is that the test is a bit biased in favor of males. This is why Jensen's analysis of sex differences in the *g* derived from the test gives a somewhat inflated male advantage of 5.49 IQ points. (3) The most anomalous of the sex differences is on the GATB with its 7.91 IQ point female advantage. There are two problems with the test. First, it has too few subtests for the extraction of a reliable *g*. Jensen states that "the extraction of *g* as a second-order factor in a hierarchical factor analysis requires at least nine tests from which at least three primary factors can be obtained" (p. 85). The GATB contains only eight tests so the extraction of *g* from it is invalid by Jensen's own rule. Secondly, the GATB contains three cognitive tests which show a male advantage of 0.63 IQ points and five perceptual-motor tests which show a female advantage of 9.9 IQ points (Jensen, 1998, p. 543). The large number of perceptual-motor tests in the battery violates Jensen's second rule for the extraction of *g*, namely that "the particular collection of tests used to estimate *g* should come as close as possible, within a limited variety of tests, to being representative of all types of mental tests" (p. 85). The GATB does not fulfil this condition and yields a large female advantage on *g* for the simple reason that it is packed with perceptual-motor tests on which females do well.

The errors in Jensen's analysis of the five tests to determine the issue of sex differences in *g* are due to two of them being based on children and to his use of the GATB, which does not meet his own rules for a suitable test from which *g* can be extracted. There is nothing wrong with his method of extracting the first principal component, identifying it with *g* and measuring sex differences in this *g*, so long as the conditions he stipulates concerning the test are observed. On the other hand, there is little point in doing this because the global IQ obtained by summing the subtests yields closely similar results. In the case of the Wechsler tests, the use of Jensen's method increases the male advantage by around a third. This is illustrated by the sex difference on the WISC-R, on which males obtain a higher mean full scale IQ of 1.7 IQ points and a higher *g* of 2.83 IQ points calculated by Jensen's method. The reason why a larger male advantage is obtained by Jensen's method is that males tend to score higher than females on the most *g* loaded tests, while the only test on which females consistently outperform males is coding/digit symbol, which has the lowest *g* loading. If Jensen had calculated sex differences on *g* on the 17 Wechsler samples summarized in the work of Lynn (1994) and Table 1, he would have found that males score higher than females in all of them and concluded that males have higher *g*.

Conclusions

The Ankney–Rushton anomaly presents a major problem for the accepted view that there is no sex difference in general intelligence. Three conclusions are proposed for the resolution of the anomaly. (1) It cannot be solved by opaque analogies with body–brain ratios in fish and birds, according to which human males are like birds, with large brains relative to bodies, while human females are like fish, with small brains relative to bodies (Mackintosh). Nor can it be solved by the contention that the female brain is more efficient than the male, providing a compensation for its smaller size (Jensen). (2) An important key to the resolution of the Ankney–Rushton anomaly lies in the recognition that the faster maturation of girls up to the age of approximately 16-years-old accelerates their cognitive development and compensates for their smaller brain size. It follows that the sex differences in abilities appear most clearly among adults in whom the maturational processes are complete. When this starting point is adopted, the resolution of the anomaly becomes clear. It is that males do have higher mean IQs than females by approximately 4 IQ points, commensurate with their larger average brain size. This conclusion holds whether general intelligence is defined as the sum of the verbal comprehension, reasoning and spatial group factors (Lynn), as fluid intelligence or reasoning ability (Mackintosh, Jensen), or as Spearman's *g* measured from the first principal component or as the global IQ obtained from standard intelligence and aptitude tests (Jensen), so long as these fulfil the conditions stipulated by Jensen. (3) The resolution of the Ankney–Rushton anomaly among children and young adolescents up to the age of 16 is a more difficult problem and requires further attention. What is needed is the breakdown of sex differences on each major ability for each year of age. A model for the required method of analysis is provided by Alexopoulos (1996) in his study of sex differences in reasoning ability among 13–18-year-olds in Greece. Aggregation of the results showed no sex difference, but analysis of the differences for each year showed that females obtained significantly higher IQs at age 13, there were no sex differences at ages 14–15, and that males had higher IQs at ages 16–18. These intelligence differences parallel the increasing male advantage in brain size over these years. Further analyses of this kind will show how far the developmental theory can explain sex differences in intelligence in childhood and early adolescence.

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