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Testing the developmental theory of sex differences in intelligence on 12–18 year olds

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Abstract

The consensus view states that there are no sex differences in intelligence. However, Lynn (1994, 1999) has formulated a developmental theory of sex differences in intelligence that challenges that view. The theory states that boys and girls mature at different rates such that the growth of girls accelerates at the age of about 9 years and remains in advance of boys until 14–15 years. At 15–16 years the growth of girls decelerates relative to boys. As boys continue to grow from this age their height and their mean IQs increase relative to those of girls. This paper presents new evidence for the theory from the Spanish standardization sample of the fifth edition of the DAT. 1027 boys and 924 girls between 12 and 18 years were tested. The general trend shows that girls do better at the younger ages and their performance declines relative to boys among older age groups, which supports the developmental theory. The sex difference for the DAT as a whole for 18 year olds is a 4.3 IQ advantage for boys, very close to the advantage that can be predicted from their larger brain size (4.4 IQ points). The profile of sex differences in abilities among the Spanish sample is closely similar to that in the United States and Britain, which is testimony to the robustness of the difference in these different cultures.

Keywords: Sex differences; Intelligence; IQ; *g*; Development; Differential Aptitude Test; DAT

1. Introduction

For the best part of a century it has been asserted that there is no sex difference in intelligence. In 1916, Lewis Terman (1916) adapted the Binet test and standardized it in the United States as

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the Stanford-Binet test on approximately 1000 4–16 year olds. In this sample girls obtained a slightly higher average IQ than boys but "the superiority of girls over boys is so slight . . . that for practical purposes it would seem negligible" (pp. 69–70). A few years later, in Britain, Spearman (1923) asserted that there is no sex difference in *g*. In his 1971 textbook, Cattell (1971) concluded that "it is now demonstrated by countless and large samples that on the two main general cognitive abilities—fluid and crystallized intelligence—men and women, boys and girls, show no significant difference" (p. 131). Twelve years later, Court (1983) in a review of 118 studies on sex differences on the Raven Progressive Matrices (Raven, 1981), widely regarded as one of the best tests of general intelligence or *g*, concluded that "the accumulated evidence at all ability levels indicated that a biological sex difference cannot be demonstrated for performance on the Raven's Progressive Matrices" (p. 68). In his textbook, Brody (1992) concluded that "gender differences in general intelligence are small and virtually non-existent (p. 323). Mackintosh (1996) writes that "there is no sex difference in general intelligence worth speaking of" (p. 567). Jensen (1998) concludes that "no evidence was found for sex differences in the mean level of *g*" (p. 531). Lubinski (2000) that "most investigators concur on the conclusion that the sexes manifest comparable means on general intelligence" (p. 416); and Halpern (2000) that "sex differences have not been found in general intelligence" (p. 218).

This view has been challenged by the second author who has proposed a developmental theory of sex differences in intelligence (Lynn, 1994, 1999). This states that boys and girls mature physically and mentally at different rates such that the growth of girls accelerates at the age of about 9 years and remains in advance of boys until 14–15 years. At 15–16 years the physical growth and the intelligence of girls decelerates relative to boys. As boys continue to grow from this age their height and their mean IQs increase relative to those of girls. These sex differences are well established for physical growth and brain size (Eveleth & Tanner, 1990; Roche & Malina, 1983). The developmental theory of sex differences in intelligence proposes that the same differences are present for intelligence.

The developmental theory of sex differences in intelligence was formulated to explain the problem raised by Ankey (1992) and Rushton (1992) that males have greater average brain size than females, both absolutely and in relation to body size. When the theory was first formulated in Lynn (1994) the correlation between intelligence and brain size measured by magnetic resonance imaging was taken as 0.35 as reported by Willerman, Schultz, Rutledge, and Bigler (1991). From this figure, the magnitude of male IQ advantage was estimated as follows. It was shown by Ankey (1992) that the average male brain is larger that the average female brain by approximately 100 g with a standard deviation of 128 giving a male advantage of 0.78*d*. This should give males an IQ advantage of $0.78 \times 0.35 = 0.273d = 4.1$ IQ points. This calculation needs to be revised in the light of the review of 11 further studies of correlation among normal samples between intelligence and brain size measured by magnetic resonance imaging assembled by Vernon, Wickett, Bazana, and Stelmack (2000) which they calculated gives a weighted average of 0.38. Adopting this figure would give males an IQ advantage accruing from their greater average brain size of 4.4. IQ points ($0.78 \times 0.38 = 0.296d = 4.4$ IQ points). The developmental theory proposes that among adults males do have an average advantage of about this magnitude, but that among children and adolescents the male advantage is masked by the faster maturation of girls.

Evidence supporting the developmental theory of sex differences in intelligence that among adults males have an advantage of approximately 4 IQ points is presented in Lynn (1994, 1998, 1999). Lynn (1994) considered 12 datasets from the United States, Britain, Norway, Sweden, Indonesia, Northern Ireland, the Netherlands, and China. Five years later, Lynn (1999) considered 20 further datasets from the United States, Portugal, Japan, Scotland, South Africa, Estonia, Germany, Greece, Ireland, Israel, England, Hawaii, and Belgium.

Allik, Must, and Lynn (1999) report a male advantage of 11.4 IQ points for reasoning ability among applicants to the University of Tartu in Estonia. Further evidence bearing on the theory has been reported by Colom and García-López (2002) who found that among 303 male and 301 female applicants to a private university in Spain, males obtained higher IQs than females by 1.5 IQ points on the Cattell Culture Fair Test and 4.2 IQ points on the Advanced Progressive Matrices. However, females scored 2.8 IQ points higher on the reasoning test of the PMA. Since all three tests measure reasoning ability, the inconsistency between the results is surprising. When the three results are averaged, males obtain an advantage of 1 IQ point. The divergent results can probably be explained by differences in the tests and samples.

In this paper, we present new evidence for the developmental theory of sex differences in intelligence from the Spanish standardization sample of the Differential Aptitude Test (5th ed., or DAT-5). The original DAT was constructed in the United States and contains eight subtests: Abstract Reasoning (AR) (non-verbal reasoning); Verbal Reasoning (VR); Numeric Ability (NA) (arithmetic); Clerical Speed and Accuracy (CSA) (perceptual speed); Space Relations (SR) (three-dimensional spatial ability); Mechanical Reasoning (MR); Spelling (S), and Language (L). The original DAT is designed for the age range 14 through 18 years and adults. The test has been standardized four times in the United States: in 1947, 1962, 1972, and 1980. Sex differences on the four American standardizations have been calculated by Feingold (1988) and in general confirm the developmental theory. For Verbal reasoning, Abstract Reasoning, Numeric Ability, Space Relations, and Mechanical Reasoning, the average scores of boys increased steadily relative to those of girls in each year from 14 through 18. However, for Spelling, Language, and Clerical Speed and Accuracy, the sex difference favoring girls remained approximately constant over the 5-year age range. The original DAT was standardized in Britain in 1977–1978 on a sample of approximately 10,000 14–18 year olds. The sex differences for each test at each age have been reported in Lynn (1992) and are closely similar to those in the American standardization samples. The purpose of the present paper is to examine whether the differences reported by Feingold for the American standardization samples and Lynn for the British standardization sample for the DAT are present in the Spanish standardization sample for the DAT-5.

2. Method

The Differential Aptitude Test (DAT-5) was standardized in Spain in 2000 after the last American edition published in 1990 (Bennett, Seashore, & Wesman, 1990). The Spanish DAT-5 contains the same subtests as the American test (5th ed.), except that it does not have tests of Spelling and Language (Spelling is substituted by a test of Orthography that closely resembles the original Spelling test). The DAT-5 is suitable for administration from 12 years onwards. The age groups of interest for this paper are 12–18 year olds. The standardization sample for 12–18 year olds comprised 1027 boys and 924 girls (specific sample sizes are shown in Table 1). The standardization sample was drawn as representative with respect to sex, age, education, and geographical location (TEA, 2000).

Table 1
Samples size, means, and standard deviations for boys and girls for each year for each of the seven subtests of the DAT-5 (Spanish standardization) [The brain size difference is taken from Lynn (1994, Table 4, p. 266)]

		12 years			13 years			14 years			15 years			16 years			17 years			18 years		
		N	Mean	S.D.	*N*	Mean	S.D.	*N*	Mean	S.D.	*N*	Mean	S.D.	*N*	Mean	S.D.	*N*	Mean	S.D.	*N*	Mean	S.D.
VR	Boys	164	15.63	5.72	206	17.45	6.78	185	21.31	6.93	136	22.92	5.98	143	20.43	5.38	118	20.97	5.69	72	21.14	5.71
	Girls	151	17.03	5.55	142	18.64	5.97	98	21.73	7.13	162	24.09	6.11	158	19.95	5.74	133	19.53	5.67	79	19.04	5.58
	d.		−0.25*			−0.18			−0.06			−0.19			0.08			0.25*			0.37*	
NR	Boys	164	11.98	4.52	206	13.72	6.05	185	17.90	7.35	136	20.27	6.33	143	15.99	4.99	119	15.30	5.59	72	14.83	4.88
	Girls	151	11.23	4.67	142	13.32	5.44	98	16.58	6.53	162	18.93	6.08	158	15.06	4.99	133	14.13	5.38	79	13.73	4.96
	d.		0.16			0.07			0.19			0.21			0.19			0.21			0.22	
AR	Boys	163	20.02	8.89	206	20.71	8.86	184	25.16	8.92	134	28.06	7.31	143	24.90	7.66	118	23.00	7.85	70	21.76	6.39
	Girls	151	19.54	8.13	142	22.49	8.75	98	23.93	8.11	161	25.91	6.74	158	22.64	6.66	133	20.16	7.12	79	19.42	6.52
	d.		0.05			−0.20			0.14			0.31**			0.32**			0.38**			0.36*	
MR	Boys	164	27.37	8.16	204	30.44	10.06	180	35.01	10.60	126	37.19	8.37	137	36.92	9.08	120	36.84	9.45	71	35.55	8.81
	Girls	150	24.31	7.63	142	27.04	9.39	94	29.45	10.45	152	32.32	9.29	156	31.91	9.62	132	29.31	9.68	78	28.33	8.32
	d.		0.39**			0.35**			0.53**			0.55**			0.53**			0.79**			0.84**	
SR	Boys	164	18.35	7.84	201	21.01	10.04	181	26.59	11.59	128	29.13	9.27	141	26.91	9.25	114	26.75	9.57	71	25.30	9.93
	Girls	150	20.28	8.52	140	23.00	10.05	95	26.26	11.80	152	28.15	9.50	153	25.75	8.92	132	23.78	9.11	79	21.78	9.18
	d.		−0.24*			−0.20			0.03			0.10			0.13			0.32*			0.34*	
SPE	Boys	163	18.73	7.47	200	20.89	8.03	178	24.25	9.01	124	26.06	7.00	135	25.53	6.62	120	26.03	7.13	71	27.30	6.93
	Girls	151	21.98	6.86	142	22.63	7.81	89	26.13	8.55	149	29.71	5.51	153	28.58	5.62	130	27.94	6.40	78	29.08	6.15
	d.		−0.45**			−0.22*			−0.21			−0.59**			−0.50**			−0.28*			−0.27	
PSA	Boys	116	38.03	9.39	155	41.13	12.21	149	50.09	10.98	106	50.96	9.76	125	54.87	11.74	112	58.90	14.51	70	57.70	13.70
	Girls	111	42.26	11.41	96	46.49	10.83	71	49.42	13.50	126	55.02	10.22	145	56.70	13.36	114	56.74	12.72	63	56.02	10.19
	d.		−0.41**			−0.46**			0.06			−0.40**			−0.14			0.16			0.14	
Average *d*			−0.11			−0.12			0.10			0			0.09			0.26			0.28	
IQ points			−1.6			−1.8			1.5			0			1.3			3.9			4.3	
Brain size difference (cm^3)			105			102			103			120			127			156			181	

3. Results

The data have been analysed for each of the 7 years 12 through 18. Table 1 gives the numbers, the means and standard deviations for boys and girls for each year for each of the seven subtests. Below each subtest are given the sex differences expressed as *d*, denoting the difference between the two means divided by the standard deviation. Minus signs denote higher means for girls and positive signs higher means for boys. The statistical significance of the differences was tested by analysis of variance. One asterisk denotes a statistically significant difference at $P<0.05$ and two asterisks a statistically significant difference at $P<0.01$.

It will be seen that the general trend is for girls to do better at the younger ages and their performance declines relative to boys among older age groups. For instance, in verbal reasoning, girls obtain a significantly higher mean at age 12 years and a non-significantly higher mean at age 13, but at the ages of 17 and 18 boys obtain significantly higher means. The same age trends are present for all of the subtests, although for some specific subtests, boys always score higher than girls (NR) and girls always score better than boys (SPE).

The last two rows of Table 1 show the average *d*s of the seven subtests and the *d*s converted to conventional IQs. Fig. 1 displays the age trend in IQ points.

Fig. 2 summarizes the sex differences on the subtests for 18 year olds in the United States, Britain, and Spain. The differences are expressed as IQs. It will be seen that there is a considerable degree of consistency between countries. In all three countries, males obtain the highest score relative to females on mechanical reasoning and the next highest score on space relations. Males have an advantage but of lesser magnitude on verbal reasoning, numeric ability, and abstract

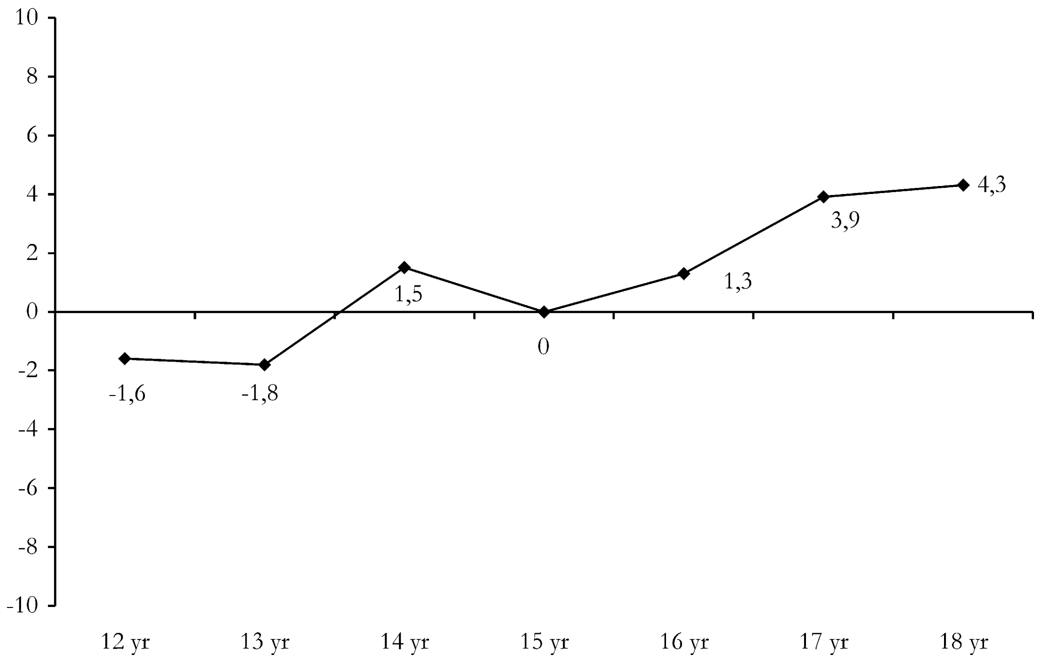

Fig. 1. IQ difference between boys and girls at different ages (minus sign denotes higher means for girls and positive sign higher means for boys).

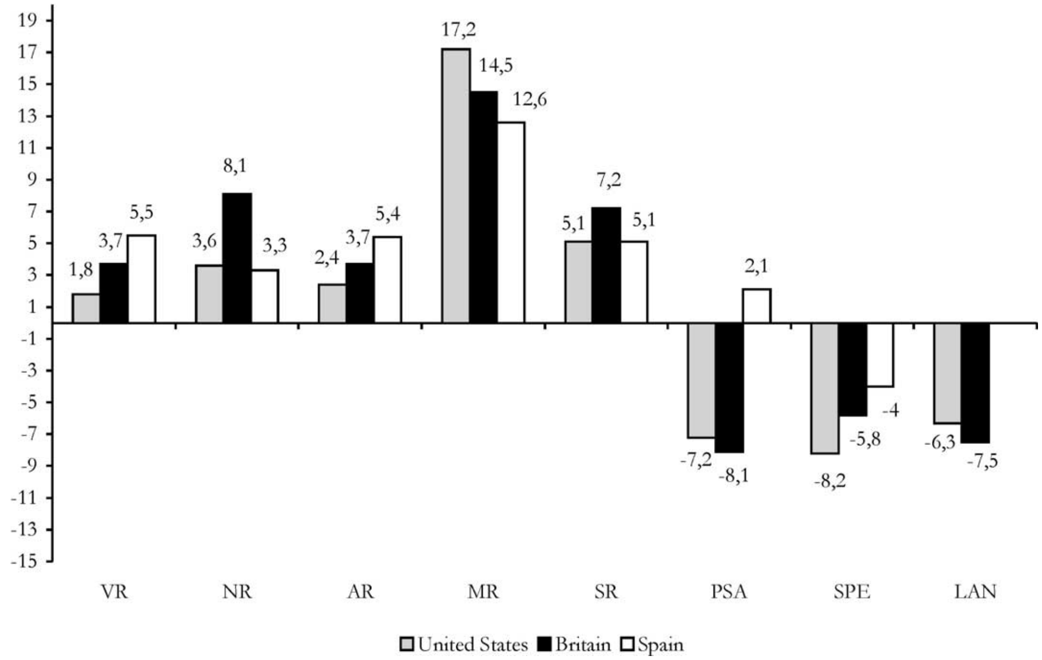

Fig. 2. Sex differences on the DAT subtests for 18 year olds in the United States, Britain, and Spain (IQ points).

reasoning. The only major inconsistency between the three countries is that females perform better than males on clerical speed and accuracy in the United States and Britain, but not in Spain. Females also perform better than males in Spelling in the United States, Britain, and Spain. They also perform better than males in Language in the United States and Britain (this test was not included in the Spanish standardization).

4. Discussion

The results contain three points of interest. First, they confirm the developmental theory of sex differences in intelligence in so far as virtually all the results show that girls aged 12–13 perform better relative to boys as compared with girls aged 14–15, and that girls aged 14–15 perform relatively better as compared to boys than girls aged 16–18. The results show that the performance of girls declines relative to that of boys from the age of 14–15 onwards.

Second, the sex difference for the test as a whole for 18 year olds is a 4.3 IQ point advantage for males. We calculated in the introduction that the male advantage accruing from their greater average brain size should be 4.4 IQ points. The result is clearly very close to the theoretical prediction. However, the magnitude of the sex difference in the global IQ obtained from a battery of different tests depends upon the abilities represented in the battery.

Third, irrespective of the developmental trends, the profile of sex differences in abilities among the Spanish sample is closely similar to that in the United States and Britain. The similarity of these profiles is testimony to the robustness of the difference in these different cultures.

The last row of Table 1 shows the difference in brain size between boys and girls from 12–18 year olds taken by Lynn (1994) from Roche and Malina (1983) and Rushton (1992). It can be seen that the boys' advantage in brain size increases from 15 years onwards. This pattern conforms to the prediction made from the developmental theory: "sex differences in intelligence should run in synchrony, year by year, with differences in brain size" (Lynn, 1999, p. 3).

Some researchers have challenged the view that there is a sex difference in intelligence, relying on a method proposed by Jensen (1998) called the "method of correlated vectors". Jensen (1998) proposes that general intelligence should be conceptualised as psychometric *g*. General intelligence is represented by a column-vector defined by the *g* loadings of several diverse tests. The scientific construct of general intelligence rests on the correlations among test scores, rather than on their summation. *g* is a source of variance evidenced by the correlation between several diverse tests, each of which reflects general intelligence (*g*), group abilities, and specific skills. The method compares the vectors defined by the *g* loadings of a variety of tests and the standardized mean sex differences in those tests expressed as *d*. The statistical test of the hypothesis concerning mean sex differences is the correlation between the vector of the tests' *g* loadings and the vector of standardized sex differences on each of the tests. A positive correlation means that the higher the *g* loading of the test, the higher the mean sex difference. However, the mean correlation found by Jensen (1998) after the analyses of five different batteries was 0.116, a value suggesting a negligible sex difference in *g*. Colom, Juan-Espinosa, Abad, and García (2000) used the method of correlated vectors with the largest sample on which a sex difference in *g* has ever been tested ($N = 10{,}475$). They found a mean correlation of 0.000. Colom, García, Juan-Espinosa, and Abad (2002) used the same method with the Spanish standardization of the WAIS-III ($N = 1369$) and found a correlation of 0.06. Therefore, their findings are consistent with those of Jensen (1998): there is a negligible sex difference in general intelligence defined as *g*.

Taking these studies into account, we have performed several factor analyses to obtain *g* as the first principal un-rotated factor (principal axis factoring) for each age considered in the present study. The vector of *g* loadings for each age was correlated with the vector defined by the standardized differences between boys and girls of each age. The computed Spearman rank-order correlations were +0.64, +0.45, +0.32, +0.54, +0.86, +0.89, and +0.82, respectively. Thus, there is a positive association (+0.65 on average) between the *g* factor and the sex differences in the DAT-5 subtests.

Those analyses confirm Lynn's main criticism on the method of correlated vectors as a way to illuminate the problem of sex differences in intelligence: the nature of *g* depends on the kind of tests in the battery from which it was extracted. Furthermore, the Spearman rank-order correlation is always computed on a small numbers of tests, which makes the method especially sensitive to Type II errors.

Summing up, the available evidence supports Lynn's view that males have an intelligence advantage among adults of approximately 4 IQ points, although this advantage is less discernible among children and young adolescents. Nearly 40 datasets support this conclusion. The consensus view that there is no sex difference in intelligence is wrong. Moreover, as the results shown in the present paper demonstrate, the main prediction of the developmental theory seems virtually correct. 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. From the age of 16 years onward, the growth of girls decelerates relative to that of boys. The effect of this is that a male advantage of about 4 IQ points develops from the age of 16 into adulthood, consistent with their larger average brain size.

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