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Sex differences on the progressive matrices among adolescents: some data from Estonia

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Abstract

It has long been asserted that there are no sex differences on the Progressive Matrices. Contrary to this position, it has been contended by Lynn (1994, 1998) that there is a small difference favoring females from the age of approximately 9–14 years, and a difference favouring males from the age of 16 onwards, reaching approximately 2.4 IQ points among adults. Data to test these two theories are reported from a standardization of the Progressive Matrices on a sample of 2689 12–18 year olds in Estonia. The results confirm the Lynn theory and show a female advantage of 3.8 IQ points among 12–15 year olds and a male advantage of 1.6 IQ points among 16–18 year olds. Boys had a significantly larger standard deviation than girls. The results provide further confirmation that in early adolescence girls outperform boys on abstract (non-verbal) reasoning ability but that in later adolescence boys outperform girls.

Keywords: Sex differences; Intelligence; Progressive matrices

1. Introduction

For almost a century it has been repeatedly asserted that there is no sex difference, or only a negligible sex difference, in "general intelligence". This view was advanced in the first decade of the twentieth century by Terman (1916, pp. 69–70) on the basis of his American standardisation sample of 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". In the next decade Spearman (1923)

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asserted that there is no sex difference in *g*, the general factor of all cognitive tests and frequently equated with "general intelligence".

The conclusion that there is no sex difference in general intelligence has been restated down the decades by leading authorites. Thus "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 differences" (Cattell, 1971, p. 131); "gender differences in general intelligence are small and virtually non-existent" (Brody, 1992, p. 323); "no evidence was found for sex differences in the mean level of *g*" (Jensen, 1998, p. 531); "there is no sex difference in general intelligence worth speaking of" (Mackintosh, 1996, p. 567); "most investigators concur on the conclusion that the sexes manifest comparable means on general intelligence" (Lubinski, 2000, p. 416); "sex differences have not been found in general intelligence" (Halpern, 2000, p. 218).

After many decades of consensus, the position that men and women are of equal average intelligence has been challenged by Lynn (1994, 1998, 1999), who has maintained that among adults males have higher average IQs than females by 3.8 IQ points. This figure is made up of a male advantage of 2.1 IQ points for reasoning ability, 1.7 IQ points for verbal ability and 7.5 IQ points for spatial ability. In this analysis the sex difference in reasoning ability was disaggregated to a male advantage of 1.8 IQ points for verbal reasoning and of 2.4 IQ points for abstract (non-verbal) reasoning ability. It is contended that the male advantage of 3.8 IQ points is consistent with, and is caused by, the larger male brain, which from the age of 15 years onwards is about 10% greater than the average female brain. A further component of this theory is that girls mature faster than boys, particularly during the growth spurt during the ages of around 9–12 years. This gives girls a slight advantage on abstract reasoning ability between these ages, but this is replaced by an advantage for boys emerging at the ages of 15–16 years and persisting into adulthood. This theory has been called "the developmental theory of sex differences" because its central contention is that the direction and magnitude of the sex differences in intelligence needs to be analysed developmentally.

In this paper we focus on sex differences on Raven's Progressive Matrices. This is a particularly interesting issue because the Progressive Matrices is widely regarded as the best test, or one of the best tests, of abstract or non-verbal reasoning ability, and this is itself widely regarded as the essence of "fluid intelligence" and of Spearman's *g*. Thus, Mackintosh (1996, p. 564) contends that abstract reasoning ability and "fluid intelligence" (Gf) can be equated with "general intelligence" and that the Progressive Matrices is "the paradigm test of non-verbal, abstract reasoning ability". Similarly, Jensen (1998, p. 541) concludes that "the Raven tests, when compared with many others, have the highest *g* loading" and are therefore the best single test for the measurement of *g*.

Those who have discussed the issue of sex differences on the Progressive Matrices have concluded that there is none, consistent with their conclusion there is no sex difference in "general intelligence". Shortly after the test was published, it was stated by Raven (1939, p. 30) that in the standardisation data "there was no sex difference, either in the mean scores or the variance of scores, between boys and girls up to the age of 14 years. There were insufficient data to investigate sex differences in ability above the age of 14". This conclusion was endorsed by Court (1983) in a review of 118 studies on sex differences on the Progressive Matrices that concluded that some studies found higher mean scores by males, others found higher mean scores by females, and yet others showed no difference in mean scores. From these inconsistent results he concluded that "the accumulated evidence at all ability levels indicates that a biological sex difference cannot be demonstrated for performance on the Raven's Progressive Matrices" (p. 68). Court's conclusion has been accepted by Mackintosh (1996) who summarises it as showing that "large scale studies of Raven's tests have yielded all possible outcomes, male superiority, female superiority and no difference" (1996, p. 564). Jensen also relies on Court's review for his conclusion that there is no sex difference on the Progressive Matrices and that this confirms his conclusion that there is no sex difference in *g*: "consistent with this finding of a near-zero sex difference in *g* is the fact that there is no consistent sex difference on Raven's Standard Progressive Matrices (for adults) or on the Coloured Progressive Matrices (for children)" (Jensen, 1998, p. 541).

Despite this reliance on Court's review, this cannot be accepted as a satisfactory basis for the conclusion that there are no sex differences on the Progressive Matrices. The review has at least four deficiencies. First, it is almost 20 years old and a number of important studies of this question have appeared subsequently and need to be considered. Second, the studies summarized in the review consist of diverse and unrepresentative samples including psychiatric patients, deaf children, retarded children, shop assistants, clerical workers, British, Indian and French university students, primary school children, secondary school children, Native Americans and Eskimos. Court warns that many of these studies are based on samples that cannot be regarded as representative of males and females. For instance, there are two studies showing that among British military personnel in World War 2 female patients suffering neurotic breakdown obtained higher scores on the Progressive Matrices than males, for which Court reports that the authors of the studies believed that the reason for this was "probably due to the biased selection procedures in favour of bright women in the British Armed Forces" (Court, 1983, p. 60). These are two of the many studies in Court's review on which no value can be placed for the assessment of sex differences in the general population. With such diverse and unrepresentative samples in Court's review, it is not surprising that in some studies higher scores were achieved by males, in others higher scores were achieved by females and in others there were no sex differences. Third, Court does not provide information on the sample sizes for approximately half of the studies he lists, and where information on sample sizes is given the numbers are almost invariably too small to show whether there is a significant sex difference on the test. To detect a statistically significant difference of 2–3 IQ points between males and females among adults, as contended by Lynn, requires a sample size of around 500. Court's review gives only one study of adults with a sample size of this number or greater. This is Heron and Chown's (1967) study ($n = 600$) on which men obtained a higher mean score than women of approximately 2.8 IQ points. Nine of the studies showing no statistically significant sex differences in Court's review have sample sizes of less than 100, including those of 60 Welsh 11–12 year olds and 22 American 5 year olds. Studies of these small samples showing no significant differences between males and females have no value for the resolution of the issue of whether there are sex differences of zero or of 2–3 IQ points on the Progressive Matrices. Fourth, Court's review did not include what was arguably the most satisfactory study available at the time, namely the Hawaii study of 2353 adults on which men had an advantage of approximately 3.8 IQ points (Wilson et al., 1975). For all these reasons, Court's review cannot be accepted as an adequate basis for the conclusion that there are no sex differences on the Progressive Matrices.

The present paper presents the results of a study designed to test two rival hypotheses. The first is the Court–Jensen–Mackintosh hypothesis that there is no significant sex difference on the

Progressive Matrices. The second is the Lynn hypothesis that there are significant differences that vary in direction during adolescence such that girls obtain higher mean scores at the ages of 12–14, boys and girls obtain about the same mean scores at age 15, and boys obtain higher mean scores at the ages of 16–18.

In addition, the paper addresses the issue of sex differences in variability on the Progressive Matrices. It has sometimes been asserted that males have greater variability than females. For instance, (Eysenck, 1981, p. 42) has written that "While men and women average pretty much the same IQ score, men have always shown more variability in intelligence. In other words, there are more males than females with very high IQs and very low IQs". More recently, Lubinski (2000, p. 416) writes that "there is some evidence for slightly greater male variability". Testing this hypothesis is a subsidiary objective of the present study.

2. Method

In 2000 the Standard Progressive Matrices was standardised in Estonia on a sample of 2738 adolescents attending 6th, 8th, 10th, and 12th grades with mean ages of 12.4, 14.4, 16.1, and 17.8 years respectively. The whole age range was from 11 to 21 years. The sample included ten 11 year olds and thirty-six 19–21 year olds, and because of these very small numbers were excluded from the analysis of mean scores of boys and girls in relation to age. The sample was drawn from 26 schools from geographically different regions, including all 15 counties (*maakond*), the capital and largest city of Tallinn, the smaller cities (Tartu, Pärnu, Kohta-Järve, etc.), small towns and rural areas. Boys and girls attend mixed secondary schools in Estonia so they are very precicely matched for the socio-economic status of their families. The test was administered without time limits. Full details of this test are given by Raven (1981).

3. Results

The means scores of boys and girls on the Progressive Matrices are shown in Table 1 for each age group from 12 to 18, together with the numbers and standard deviations. The right hand column shows the same data for the total sample. The last four rows show the raw score differences between boys and girls (minus signs indicate higher means obtained by girls and positive signs indicate higher means obtained by boys); the differences expressed as d scores (the differences between the two means divided by the standard deviations; the d scores expressed as conventional IQs; and the t values for the sex differences. The t values show that the sex differences are statistically significant at age 12 ($P<0.001$), at age 13 ($P=0.05$) and for the total sample ($P<0.001$). The sex differences at the other ages are not statistically significant.

When the sample is considered as a whole, girls obtain a higher mean than boys with a d value of 0.16, equivalent to 2.3 IQ points [tested by analysis of variance, $F(1,2689)=16.33$, $P<0.001$; $t=4.03$, $P<0.001$]. When the age trend is examined, it will be seen that the general trend is for girls to obtain higher means than boys over the age range 12–15 years, and for boys to obtain higher means than girls over the age range 16–18. Tested by analysis of variance, the sex by age interaction is highly statistically significant [$F(1,2677)=6.40$, $P<0.001$].

Table 1
Sex differences on the Progressive Matrices

Age	12	13	14	15	16	17	18	Total
Boys								
Number	219	152	232	159	219	109	160	1250
Mean	44.82	45.52	49.08	49.48	52.70	52.89	52.86	49.40
S.D.	6.59	7.39	6.80	6.72	5.10	4.54	5.33	6.96
Girls								
Number	242	137	246	154	316	125	221	1439
Mean	48.13	47.48	49.16	50.73	51.87	52.51	52.66	50.43
S.D.	5.76	6.85	6.95	6.61	5.26	4.54	5.28	6.21
Boy–Girl Difference	−3.31	−1.96	−0.19	−1.25	0.83	0.38	0.20	1.03
D	−0.54	−0.26	−0.03	−0.19	0.16	0.8	0.04	−0.16
IQ	−8.1	−3.9	−0.4	−2.8	2.4	1.2	0.6	−2.3
t	5.76	2.32	0.18	1.65	1.83	0.63	0.72	4.03

Turning now to the sex differences in standard deviations, the data do not show a consistent difference between boys and girls. Boys have greater standard deviations at ages 12, 13, 15 and 18 and girls have greater standard deviations at ages 14 and 17, while at the age of 17 the standard deviations are the same. On the total sample the standard deviation for girls was 6.21 and for boys, 6.96. The greater standard deviations of boys are statistically significant for the total sample ($F = 1.26$, $P < 0.001$) and for the 12 year olds ($F = 1.31$, $P < 0.01$), tested by the Levene and Brown-Forsyth tests for equality of two variances. None of the other sex differences in variances is statistically significant.

4. Discussion

The results provide six points of interest. First, they show that when a large sample of adolescents in the age range 11–18 years is treated as a single sample, girls obtain a significantly higher mean IQ by 2.3 IQ points. This result should, however, be regarded as meaningless because it is clear from the data set out in Table 1 that both the size and direction of sex differences on the Progressive Matrices among adolescents varies with age and hence on the numbers of boys and girls in early and later adolescence in the sample.

Second, the results show that when sex differences are examined in relation to age, girls perform better at the ages of 12–15 and boys perform better from the age of 16 years onwards. These results show when a sample of adolescents has an age range spanning a number of years, it cannot be meaningfully treated as a single sample for the analysis of sex differences. Such analyses will produce conflicting results depending on the numbers in early and later adolescence. If there are large numbers in the age range 12–15 years and smaller numbers in the age range 16–18, girls will obtain higher means than boys (as in the present sample). Conversely, if there are smaller numbers in the age range 12–15 and larger numbers in the age range of 16–18, boys will obtain higher means than girls. Thus, all possible results can be obtained in analyses of sex differences on the Progressive Matrices, as Court (1983) noted. This does not mean, however, that the results of all the studies on this issue, some showing that males obtain higher means than females, some showing that females obtain higher means than males, and others showing no difference, cancel out and that the best reading of all the conflicting results is that there is no sex difference, as Court, Mackintosh and Jensen concluded. To the contrary, it means that when sex differences are analysed for each year a consistent pattern emerges with girls obtaining higher means over the age range 12–15 and boys obtain higher means over the age range 16–18.

Third, the results confirm the theory advanced in Lynn (1994) that girls have an advantage on abstract (non-verbal) reasoning ability in early adolescence and that this is replaced by an advantage for boys from the age of 16 onwards. The Lynn hypothesis does not specify precisely the magnitude of the female advantage over the years 12–15, but the present data show that the average for these years is 3.8 IQ points. Nor does the hypothesis specify precisely the male advantage in later adolescence but it states that it is around 2.4 IQ points among adults (Lynn, 1994). In the late adolescence, the male advantage should be somewhat less. In the present data, the male advantage of the 16–18 year olds averages 1.6 IQ points. This provides as close a fit as could be expected to the theory that the male advantage begins to appear at the age of around 16 years and reaches a maximum of 2.4 IQ points among adults.

Fourth, the theory that males have a higher average IQ than females was first advanced to explain the problem that males have larger average brain size (Lynn, 1994). The data reported in this paper support the theory for adolescents between the ages of 16–18. However, there remains the problem that boys have larger brains than girls throughout childhood and adolescence, as documented in Lynn (1994) and in Lynn, Allik and Must (2000). The explanation for the higher IQs obtained by girls over the age range 12–15 cannot be explained in terms of an advantage for girls in brain size. It is proposed that the explanation for the higher means obtained by girls over the age range 12–15 is most plausibly explained by the faster maturation of girls in early adolescence.

Fifth, a referee has commented that the sex difference is "so small as to have no practical value". We do not agree. The male advantage of 2.4 IQ points among adults would produce 140 males with IQs above 130 for every 100 females and approximately twice as many males with IQs above 200. This may provide part of the explanation for the preponderance of men in occupations requiring high levels of intelligence.

Six, the sex differences in standard deviations provide some confirmation of the contention of Eysenck (1981), Lubinski (2000) and others that males have larger standard deviations than females on abstract reasoning ability tested by the Progressive Matrices in so far as the greater standard deviations of boys is statistically significant for the total sample. However, the results show that the sex differences in the standard deviations of the Progressive Matrices vary with the means and approach zero among the age groups with the highest means, i.e. the 17 and 18 year olds. The correlation between means and variances across all age groups is −0.83. The sample contained larger numbers in the age range 12–15 where the mean scores of boys are generally lower than those of girls and hence their standard deviations are greater. Because the mean and standard deviation of the Progressive Matrices are highly correlated and confounded, there is no easy way to test the hypothesis that the standard deviation of males is invariably greater than that of females.

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