Sex Differences in Intelligence: The Developmental Theory

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It is a paradox that males have a larger average brain size than females, that brain size is positively associated with intelligence, and yet numerous experts have asserted that there is no sex difference in intelligence. This paper presents the developmental theory of sex differences in intelligence as a solution to this problem. This states that boys and girls have about the same IQ up to the age of 15 years but from the age of 16 the average IQ of males becomes higher than that of females with an advantage increasing to approximately 4 IQ points in adulthood.
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There is an inconsistency between the assertion of numerous experts that there is no sex difference in general intelligence and the theoretical expectation that the larger average brain size of men should give them a higher average IQ than women. This paper presents the *Developmental Theory* of sex differences in intelligence as a solution to this problem. The term general intelligence is used in the sense defined by Johnson, Carothers and Deary (2009) "to mean the ability to use combinations of pre-existing knowledge and abstract reasoning to solve any of a variety of problems designed to assess the extent to which individuals can benefit from instruction or the amount of instruction that will be necessary to attain a given level of competence" and measured as the IQ derived as the average of cognitive abilities obtained in tests like the Wechsler, the Stanford-Binet, the Cattell Culture Fair and numerous others.

The equal intelligence of males and females has been almost invariably asserted from the early twentieth century up to the present. Two of the first to advance this conclusion were Burt and Moore (1912) and Terman (1916). In the second half of the century it was frequently restated. Typical conclusions by leading authorities are those of Cattell (1971, p. 131): “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"; Brody (1992, p. 323): "gender differences in general intelligence are small and virtually non-existent"; Eysenck (1981, p. 40): "men and women average pretty much the same IQ"; Herrnstein and Murray (1994, p. 275): "the consistent story has been that men and women have nearly identical IQs"; Mackintosh (1996): "there is no sex difference in general intelligence worth speaking of "; and Hutt (1972, p. 88): "there is little evidence that men and women differ in average intelligence". Others who stated the same conclusion include Maccoby and Jacklin (1974, p. 65) and Geary (1998, p. 310).

The assertions that males and females have the same average IQ continued to be made in the twenty-first century. Lubinski (2000): "most investigators concur on the conclusion that the sexes manifest comparable means on general intelligence "; Colom et al. (2000): "we can conclude that there is no sex difference in general intelligence"; Loehlin (2000, p. 177): "there are no consistent and dependable male-female differences in general intelligence"; Lippa (2002): "there are no meaningful sex differences in general intelligence"; Jorm et al. (2004): "there are negligible differences in general intelligence"; Anderson (2004, p. 829): "the evidence that there is no sex difference in general ability is overwhelming"; Spelke and Grace (2007, p. 65): "men and women have equal cognitive capacity"; Hines (2007, p. 103): "there appears to be no sex difference in general intelligence; claims that men are more intelligent than women are not supported by existing data"; Haier (2007): "general intelligence does not differ between men and women"; Pinker (2008, p. 13): "the two sexes are well matched in most areas, including intelligence"; Halpern (2007, p. 123): "there is no difference in intelligence between males and females…overall, the sexes are equally smart"; Mackintosh (2011, p. 380): "the two sexes do not differ consistently in average IQ"; Halpern (2012, p. 233): "females and males score identically on IQ tests."

1. Sex Differences in Brain Size

It is well established that there is a positive association between brain size and intelligence and that males have a larger average brain size than females. The positive association between brain size and cognitive ability was first shown by Galton (1888) in a study of students at Cambridge University that reported a correlation of .11 between head size and examination results. This positive association was confirmed in a review of studies of head circumference and IQ giving a correlation of .30 (Van Valen, 1974). The first study of intelligence and brain size measured by MRI (Magnetic Resonance Imaging) was reported by Willerman et al. (1991), who estimated the correlation at .35. This association has been further confirmed in subsequent studies, e.g. at *r* = .43 (Raz et al., 1993), .40 for college students in Turkey (Tan et al., 1999), and .33 in a meta-analysis of 37 studies (McDaniel, 2005).

The larger average brain size of men than of women is also well-established. It was reported by Broca (1861) and confirmed when controlled for body size by Ankney (1992) and Rushton (1992). Thus, there is the paradox that brain size is positively associated with intelligence, that males have a larger brain size than females, that it appears to follow that males should have a higher average IQ than females, yet numerous experts have asserted that males and females have the same average intelligence.

There has been some acknowledgement of the paradox that men have a larger average brain size than women, that brain size is positively associated with intelligence, and yet males and females apparently have the same average intelligence. Butterworth (1999, p. 293) noted the problem, writing that “women’s brains are 10% smaller than men’s, but their IQ is on average the same” but did not offer a solution to the paradox. Gould (1996) wrote that since women with their smaller average brain size are just as intelligent as men, this disconfirms “the myth that group differences in brain size bear any relationship to intelligence”. Halpern (2012, p. 233) also asserted that “there is no evidence that larger brains are, in any way, better than smaller brains”, but the results of numerous studies do not support this contention.

An attempt to resolve the paradox was made by Jensen (1998), who suggested that females have the same number of neurons in the brain as males but these are smaller and more closely packed. This improbable hypothesis has been shown to be incorrect by Pakkenberg and Gundersen (1997), who reported that men have an average of four billion more neurons than women, a difference of 16 percent. Further data showing that men have more neurons than women have been given by Pelvig et al. (2008).

2. The Developmental Theory

In 1994 I presented the *Developmental Theory* as solution to the paradox that intelligence is positively associated with intelligence, that males have a larger average brain size than females and yet numerous experts have asserted that males and females have the same average intelligence (Lynn, 1994). This stated that boys and girls do have about the same IQ up to the age of 15 years but from the age of 16 the average IQ of males becomes higher than that of females with an advantage increasing to approximately 4 IQ points in adulthood. The reason for this is that the height, weight and crucially the brain size of males increases relative to that of females from the age of 16. One effect of the increasing brain size of males is that their intelligence increases relative to that of females. Data supporting this theory are shown in Table 1.

Table 1. *Sex differences in brain size (female as % of male) and intelligence (ds; positive signs denote boys score higher), ages 12-21. AR, abstract reasoning.*

	12	13	14	15	16	17	18	19	20	21	Reference
Female brain size	92.2	92.5	92.6	91.5	91.2	89.2	-	-	-	86.6	Roche & Malina, 1983; Rushton, 1992
IQ (AR)	-	-	0.00	0.04	0.09	0.10	0.16	-	-	-	Feingold, 1988
IQ (AR)	-	-	0.06	0.08	0.08	0.19	0.25	-	-	-	Lynn, 1992
IQ Spain	- 0.11	-0.12	0.10	0.00	0.09	0.26	0.28	-	-	-	Colom & Lynn, 2004
US:whites	-	-	-	-0.03	0.26	0.29	0.17	0.23	0.32	0.41	Meisenberg, 2009
US: blacks	-	-	-	-0.11	0.07	0.05	0.07	0.00	0.10	0.10	Meisenberg, 2009
US: whites	0.08	0.10	0.02	0.16	0.23	0.26	-	-	-	-	Nyborg, 2015
US: blacks	- 0.13	-0.18	-0.04	-0.19	-0.34	0.43	-	-	-	-	Nyborg, 2015
US: Hispanics	0.00	0.11	-0.08	0.24	-0.03	0.30	-	-	-	-	Nyborg, 2015

Row 1 gives the cranial capacity of females as a percentage of that of males calculated from the head width, length and height data given by Roche and Malina (1983, p. 483) and Rushton (1992) using the Lee and Pearson (1901) formula for converting these dimensions to cranial capacity. Note that the cranial capacity of females as a percentage of that of males declines from the ages of 15 to 17 (data from Roche and Malina, 1983) and declines further at age 21+ (data from Rushton, 1992).

Row 2 gives the American IQ (Abstract Reasoning) data from Feingold (1988) showing an increasing male advantage from ages 14 through 18. Row 3 gives the British-scaled IQ (Abstract Reasoning) data from Lynn (1992) also showing an increasing male advantage from ages 14 through 18. Row 4 gives the data from the Spanish DAT (Differential Aptitude Test) showing negligible differences from age 12 to 15, followed by increasing male advantages from ages 16 through 18, when the male advantage reaches 0.28*d* (4.2 IQ points). Row 5 gives results for 15 to 21 year old whites for the ASVAB (Armed Services Vocational Aptitude Battery) scored for *g* showing a female advantage at age 15 followed by increasing male advantages from age 16 reaching 0.41*d* (6.15 IQ points at age 21 (average of age 21-23). Row 6 gives results from the same data for blacks also showing a female advantage at age 15 followed by male advantages from age 16 but these are very small and not statistically significant. Rows 7, 8 and 9 give results for whites, blacks and Hispanics for the CAT (Cognitive Abilities Test) scored for *g* for 12 to 17 year olds. Row 7 shows that for whites there are negligible differences among 12-15 year olds followed by a male advantage among 16 and then among 17 year olds of 0.26*d.* Row 8 shows that for blacks there are female advantages among 12-16 year olds followed by a male advantage among 17 year olds of 0.43*d*. Row 9 shows that for Hispanics there are inconsistent results among 12-16 year olds followed by a male advantage among 17 year olds of 0.30*d*.

To calculate the magnitude of the higher adult male IQ that would be predicted from the larger male brain size I took Ankney's figure of the male-female difference in brain size expressed in standard deviation units of 0.78*d* and Willerman et al.'s (1991) estimate of the correlation between brain size and intelligence of 0.35. These figures would give adult males a higher average IQ of 0.78 multiplied by 0.35 = .27*d* = 4.0 IQ points. In my 1994 paper I presented data showing adult male advantages of 1.7 IQ points on verbal ability, 2.1 IQ points on verbal and non-verbal reasoning ability, and 7.5 IQ points on spatial, giving an average male advantage among adults of 3.8 IQ points and thus very close to the predicted advantage of 4.0 IQ points. I published further data for this male advantage in Lynn (1998, 1999). The male advantages given by Meisenberg (2009) given in Table 1 of 0.42*d* for whites and 0.30*d* for blacks are reasonably consistent with these results.

Further studies showing that a male IQ advantage begins to appear from the age of 16 years have been reported by Nyborg (2003, p. 212; 2005) giving a male advantage of 5.5 IQ points in a Danish adult sample; and by Jackson & Rushton (2006) who reported a male advantage of 3.6 IQ points in a sample of 100,000 17-18 year olds on the American Scholastic Assessment Test.

3. The Progressive Matrices

The great majority of scholars have ignored my solution to the sex difference in intelligence and brain size paradox and continued to assert that there is no sex difference in general intelligence. The only scholar who disputed my thesis was Mackintosh (1996, p. 567), who argued that Raven's Progressive Matrices is one of the best measures of *g* and that on this test "there is no sex difference in general intelligence worth speaking of …large scale studies of Raven's tests have yielded all possible outcomes, male superiority, female superiority and no difference… there appears to be no difference in general intelligence." He reiterated this conclusion in a subsequent paper contending that there is at most "only a very small difference consisting of no more than 1-2 IQ points among adults either way" (Mackintosh, 1998).

In response to this criticism, Irwing and I published a meta-analyses of sex differences on the Progressive Matrices among general population samples that showed that males obtain higher IQs than females from the age of 16 years reaching 5 IQ points among adults (Lynn & Irwing, 2004), and a meta-analysis of sex differences on the Progressive Matrices among college student samples that concluded that males have an advantage of 4.6 IQ points (Irwing & Lynn, 2005). These results have been confirmed in subsequent studies, e.g. by a higher male IQ of 4.35 points in a Scottish sample (Deary et al., 2004) and by a higher male IQ of 4.05 in a Serbian sample (Čvorović & Lynn, 2014).

4. The Wechsler Tests

Our meta-analyses showing an adult male advantage on the Progressive Matrices have been criticized by Cooper (2015, p. 207), who argues that sex differences in intelligence would be best examined by "averaging performance across a number of disparate tasks as with tests such as the WAIS". He seems to have been unaware that I had presented the results of fourteen studies of the sex differences on the Wechsler tests in my 1994 paper and showed that in eight studies of 6-16 year olds on the WISCs males obtained higher IQs than females by an average of 2.35 IQ points, and that in six studies of adults on the WAIS males obtained higher IQs than females by an average of 3.08 IQ points (Lynn, 1994, p. 259).

Cooper was right to suggest that the Wechsler tests provide some of the best data with which to evaluate the no-sex-difference theory and the male advantage theory because a number of them have been standardized on representative samples and they measure a wide range of verbal, spatial, perceptual, reasoning and memory abilities that are averaged to provide the Full Scale IQ as a measure of general intelligence. Advocates of the no IQ sex difference theory have asserted that males and females obtain the same IQs on these tests. Thus, it has been asserted by Halpern (2000, p. 91) that the WAIS Full Scale IQ "does not show sex differences". This assertion was repeated by Anderson (2004, p. 829): "The evidence that there is no sex difference in general ability is overwhelming. This is true whether general ability is defined as an IQ score calculated from an omnibus test of intellectual abilities such as the various Wechsler tests, or whether it is defined as a score on a single test of general intelligence, such as the Raven's Matrices". The same assertion has been made by Haier et al. (2004, p. 1): "Comparisons of general intelligence assessed with standard measures like the WAIS show essentially no differences between men and women." In the fourth edition of her textbook on sex differences in intelligence, Halpern (2012, p. 115) states that on the standardization sample of the American WAIS-IV "the overall IQ score does not show sex differences". We consider now how far the evidence supports these assertions that there is no sex difference in intelligence measured by the Wechsler tests.

5. The WPPSI

The Wechsler Preschool and Primary Scale of Intelligence (WPPSI) was constructed in the United States in the mid-1960s by Wechsler (1967) and was designed for children aged between 4 and 7 years. It consists of five verbal subtests designated information, vocabulary, arithmetic, similarities and comprehension that are averaged to give the Verbal IQ, and five performance subtests designated animal house, picture completion, mazes, geometric design and block design that are averaged to give the Performance IQ. The Verbal IQ and Performance IQ are averaged to give the Full Scale IQ. Subsequent standardizations of the WPPSI designated the WPPSI-R and the WPPSI-III have been published in the United States.

Six studies of the sex differences on the WPPSI are summarized in Table 2. The data for the United States and Japan are for standardization samples. In the USA, Canada and Iran girls obtained slightly higher Full Scale and Verbal IQs than the boys while in China, England and Japan the boys obtained slightly higher Full Scale and Performance IQs but the girls obtained a higher Verbal IQ. All sex differences in the American, English, Canadian and Japanese samples are small. In the Iranian sample the girls obtained an appreciably higher Full Scale, Verbal and Performance IQ than the boys but the sample is very small at 54 and the sex differences are not statistically significant. The results as a whole suggests there is no significant sex difference at the age of 4 to 7 years.

Table 2. *Sex differences on the WPPSI: ds for Full Scale (FS), Verbal (V) and Performance IQ (P). Positive signs denote boys score higher.*

Country	N	FS	V	P	Reference
Canada	109	-0.03	-0.07	0.00	Miller & Vernon, 1996
China	1331	0.14	0.16	0.11	Liu & Lynn, 2011
England	150	0.14	0.10	0.14	Yule et al., 1969
Iran	54	-0.23	-0.42	-0.27	Ghaderpanah et al., 2015
Japan	599	0.06	-0.01	0.11	Hatttori, 2000
USA	1199	-0.06	-0.02	-0.01	Kaiser & Reynolds, 1985

6. The WISC

The Wechsler Intelligence Scale for Children (WISC) was constructed in the United States in the mid-1940s by Wechsler (1949) and was designed for children aged between 6 and 16 years. It consists of six verbal subtests designated Information, Vocabulary, Arithmetic, Similarities, Comprehension and Digit Span the first five of which are averaged to give the Verbal IQ, and six performance subtests designated Picture Completion, Picture Arrangement, Object Assembly, Coding, Block Design and Mazes, the first five of which are averaged to give the Performance IQ. The Verbal IQ and Performance IQ are averaged to give the Full Scale IQ. Subsequent standardizations of the WISC have been published in the United States and are designated the WISC-R, WISC-III and WISC-IV. The results of sex differences on the WISC tests are summarized in Table 3.

Table 3. *Sex differences on the WISCs, ds for Full Scale (FS), Verbal (V) and Performance IQ; positive signs denote boys score higher.*

Country	Test	N	FS	V	P	Reference
Bahrain	WISC-III	10	0.03	-0.10	0.04	Bakhiet & Lynn, 2015
Belgium	WISC-R	76	0.12	0.16	0.10	van der Sluis et al., 2008
China	WISC-R	223	0.28	0.30	0.21	Dai & Lynn, 1994
China	WISC-R	78	0.25	0.16	0.28	Liu & Lynn, 2015
Germany	WISC-IV	165	0.07	0.19	-	Goldbeck et al., 2010
Greece	WISC	40	0.21	0.19	0.27	Fatouros, 1972
Iran	WISC-R	140	0.04	-	-	Shahim, 1990, 1992
Israel: Jews	WISC-R	211	0.32	0.29	0.19	Lieblich, 1985
Israel: Arabs	WISC-R	63	0.41	0.43	0.43	Lieblich, 1985
Israel	WISC-R	110	0.19	0.20	0.01	Cahhan, 2005
Libya	WISC-R	21	0.10	-0.13	0.42	Al-Shahomee et al., 2016
Mauritius	WISC-R	125	0.60	0.16	0.70	Lynn, Raine et al., 2005
Netherlands	WISC-R	202	0.14	0.16	0.08	Born & Lynn, 1994
Netherlands	WISC-R	73	0.25	0.26	0.00	van der Sluis et al., 2008
New Zealand	WISC-R	89	0.06	0.09	0.00	Lynn, Fergusson et al., 2005
Romania	WISC-R	10	0.70	0.32	0.62	Dumitrascu, 1999
Scotland	WISC-R	136	0.18	0.31	0.01	Lynn & Mulhern, 1991
Sudan	WISC-III	121	0.23	0.26	0.13	Bakhiet et al., 2016
Taiwan	WISC-III	110	0.21	0.13	0.25	Chen et al., 20116
USA	WISC	220	0.17	0.25	0.06	Seashore et al., 1950
USA	WISC-R	186	0.12	0.19	0.01	Jensen & Reynolds, 1983
USA: whites	WISC	112	0.07	-	-	Jensen & Johnson, 1994
USA: blacks	WISC	81	-0.04	-	-	Jensen & Johnson, 1994
USA	WISC-R	10	0.53	-	-	Rushton, 1997
USA	WISC-R	85	0.29	-	-	Knopik & Defries, 1998

The WISC-III and the WISC-IV are also scored from the subtests to provide four Index IQs and a Full Scale IQ. The four Index IQs are Verbal Comprehension (the sum of the Vocabulary, Similarities and Comprehension subtests), Perceptual Reasoning (designated Perceptual Organization in the WISC-III, the sum of the Block Design, Matrix Reasoning and Picture Completion subtests), Working Memory (designated Freedom from Distractibility in the WISC-III, the sum of the Digit Span and Letter-Number Sequencing subtests), and Processing Speed (the sum of the Coding and Digit Symbol subtests). The Index IQs are averaged to give the Full Scale IQ. The results of these studies of sex differences on the WISC-III and IV tests are summarized in Table 4.

Table 4. *Sex differences on the WISC-III and WISC-IV for Full-Scale IQ (FS) and the four index IQs: Verbal Comprehension (VC), Perceptual Reasoning (PR), Working Memory (WM), and Processing Speed (PS). Differences expressed as d, positive signs denote boys score higher.*

Country	Test	N	FS	VC	PR	WM	PS	Reference
China	WISC-IV	1744	.12	.19	.26	-.08	-.19	Li et al., 2016
Germany	WISC-IV	1650	.06	.19	.13	.08	-.33	Goldbeck et al., 2010
Italy	WISC-IV	2200	-.03	.09	.04	.01	-.28	Pezzuti & Orsini, 2016
Sudan	WISC-III	1214	.23	.25	.29	.06	-.27	Bakhiet et al., 2017
Taiwan	WISC-III	1100	.21	.11	.36	.06	-.25	Chen et al., 2016
USA	WISC-III	2200	.11	.13	.08	.06	-.46	Chen et al., 2016

The studies of the WISCs for children aged between 6 and 16 years summarized in Table 3 give Full Scale IQs for 25 samples. In all of these studies boys obtained higher Full Scale IQs than girls except for American blacks. These results are confirmed by those for the six studies of WISC-III and WISC-IV given in Table 4 in five of which boys obtained higher Full Scale IQs than girls. Combining the results in Tables 3 and 4 gives 31 studies for which the median advantage of boys is .19*d,* equivalent to 2.85 IQ points. These results disconfirm the assertions cited in section 4 that there is no sex difference on the Wechsler tests and also my previous contention that there is virtually no sex difference in children up to the age of 15 years. It seems that we have all been wrong about this.

The studies of Verbal IQ in the WISCs for children aged between 6 and 16 years summarized in Table 3 give results for 20 samples. In two of these girls obtained a higher Verbal IQ than boys, namely in Bahrain and Libya. In the remaining 18 studies boys obtained higher Verbal IQs than girls. These results are confirmed by those for the six studies of the WISC-III and WISC-IV given in Table 4 in all of which boys obtained higher Verbal Comprehension IQs than girls.

Combining the results in Tables 3 and 4 gives 26 studies for which the median advantage of boys is .19*d,* equivalent to 2.85 IQ points, the same as for the Full Scale IQ. The studies of the Performance IQs on the WISCs summarized in Table 3 give results for 19 samples. In 17 of these boys obtained higher Performance IQs than girls and in two there was no difference. The median of the studies is a boys' advantage of .19*d*. The Performance IQ measures a mix of non-verbal abilities.

The results for six studies of the WISC-III and WISC-IV summarized in Table 4 show that in all of these males obtained a higher Verbal Comprehension IQ with a median advantage of .16*d,* confirming the male advantage in verbal ability shown in Table 3. Males obtained higher Perceptual Reasoning IQs with a median advantage of .16*d,* and in Working Memory IQ with a median advantage of .07*d.* On Perceptual Speed females obtained higher IQs with a median advantage of .28*d*.

7. The WAIS

The Wechsler-Bellevue Intelligence Scale (WBIS) was constructed in the United States in the mid-1940s by Wechsler and was designed for those aged 16 years into old age. It has been through four revisions designated the WAIS (Wechsler Adult Intelligence Scale), WAIS-R, WAIS-III and WAIS-IV. It consists of six verbal subtests designated Information, Vocabulary, Arithmetic, Similarities, Comprehension and Digit Span which are averaged to give the Verbal IQ, and five performance subtests designated Picture Completion, Picture Arrangement, Object Assembly, Block Design and Digit Symbol which are averaged to give the Performance IQ. The Verbal IQ and Performance IQ are averaged to give the Full Scale IQ. The results of studies of sex differences on the WAIS tests are summarized in Tables 5 and 6.

The WAIS-III and the WAIS-IV (like the WISC-III and the WISC-IV) are also scored from the subtests to provide four index IQs and a Full Scale IQ. The four index IQs are Verbal Comprehension (the sum of the Vocabulary, Similarities and Comprehension subtests), Perceptual Reasoning (the sum of the Block Design, Matrix Reasoning and Picture Completion subtests), Working Memory (the sum of the Digit Span and Letter-Number Sequencing subtests), and Processing Speed (the sum of the Coding and Digit Symbol subtests). The index IQs are averaged to give the Full Scale IQ. The results of studies of sex differences on the WAIS-III and the WAIS-IV tests are summarized in Table 6 and show that in the ten studies males obtained higher Full Scale IQs than females with a median advantage of 0.165*d* equivalent to 2.5 IQ points.

Table 5. *Sex differences of adults on the WAIS tests: Full scale (FS), Verbal (V) and Performance IQ (P) in d, positive signs denote males score higher.*

Country	Test	N	FS	V	P	Reference
China	WAIS-R	1979	0.33	0.36	-	Lynn & Dai, 1993
China	WAIS-R	120	0.43	0.42	0.44	Yao et al., 2004
Denmark	WAIS	62	0.21	-	-	Nyborg, 2005
Finland	WAIS-III	407	0.07	0.08	0.07	Finland Psych. Corp., 2006
Italy	WAIS-R	1168	0.45	0.43	0.35	Saggino et al., 2014
Japan	WAIS-R	1402	0.22	0.28	0.10	Hattori & Lynn, 1997
Netherlands	WAIS	2100	0.27	0.29	-	Stinissen, 1977
Romania	WAIS	100	0.44	0.25	0.52	Dumitrascu, 1999
Romania: Roma	WAIS	100	0.44	0.37	0.42	Dumitrascu, 1999
Russia	WAIS	296	0.13	-	-	Grigoriev et al., 2016
Russia	WAIS	1800	0.22	0.42	0.15	Grigoriev et al., 2016
Scotland	WAIS-R	200	0.39	0.43	0.28	Lynn, 1998
USA	W-Bell	235	0.59	0.63	0.35	Strange & Palmer, 1953
USA	W-Bell	153	0.20	0.52	-0.35	Norman, 1953
USA	W-Bell	392	0.29	0.34	0.22	Goolishian & Foster, 1954
USA	WAIS	1700	0.10	0.10	0.10	Matarazzo, 1972
USA	WAIS	279	0.40	0.14	0.26	Boor, 1975
USA	WAIS	588	0.17	0.21	-	Horn et al., 1979
USA	WAIS	521	0.13	-	-	Turner & Willerman, 1977
USA	WAIS	649	0.12	0.20	-0.08	Doppelt & Wallace, 1955
USA	WAIS-R	230	0.27	0.25	0.23	Arceneaux et al., 1996
USA	WAIS-R	206	0.28	0.37	-	Ilai & Willerman, 1989
USA	WAIS-R	1880	0.15	0.15	0.09	Matarazzo et al., 1986

The studies of the 23 WAIS IQs for adults summarized in Table 5 show that men obtained a higher Full Scale IQ than women in all samples. The studies of the 10 WAIS IQs for adults summarized in Table 6 again show that men obtained higher Full Scale IQs than women in all samples. The median male advantage for the 33 studies is .24*d*, equivalent to 3.6 IQ points. The median male advantage among adults of 3.6 IQ points is greater than the median advantage among children of 2.85 IQ points, confirming the thesis advanced in Lynn (1994).

Table 6. *Sex differences on the WAIS-III and WAIS-IV for Full-Scale IQ (FS) and the four index IQs: Verbal Comprehension (VC), Perceptual Reasoning (PR), Working Memory (WM), and Processing Speed (PS). Differences expressed as ds; positive signs denote males score higher*.

Country	Test	N	FS	VC	PR	WM	PS	Reference
Brazil	WAIS-III	3494	.07	-	-	-	-	Victora et al., 2015
Canada	WAIS-III*	1104	.11	-	-	-	-	Longman et al., 2007
Chile	WAIS-IV*	887	.20	.16	.26	.25	.03	Diaz & Lynn, 2016
Germany	WAIS-IV	137	.08	-	-	-	-	Lepach et al., 2015
Hungary	WAIS-IV*	1110	.08	.12	.18	.23	-.32	Rósza et al., 2010
Korea, South	WAIS-IV*	1228	.31	.36	.35	.46	-.33	Lynn & Hur, 2016
Netherlands	WAIS-III	519	.24	.30	.23	.26	-.45	van der Sluis, 2006
Spain	WAIS-III*	1369	.24	.13	.24	.24	.18	Colom et al., 2002
USA	WAIS-III*	2450	.18	.23	.22	.24	-.45	Irwing, 2012
USA	WAIS-IV*	2200	.15	.23	.24	.22	-.30	Piffer, 2016

*standardization samples

The Verbal IQs of adults summarized in the 20 studies given in Table 5 and in the 7 studies given in Table 6 show that in all samples men obtained a higher Verbal IQ than women. The median male advantage for the 27 studies is .23*d*, equivalent to 3.45 IQ points. This male advantage is greater than that of 2.85 IQ points among children and provides further confirmation that the male IQ advantage among adults is greater than among children. These results of the seven studies of the WAIS-III and WAIS-IV given in Table 6 show that in all of these males obtained higher Verbal Comprehension IQs with a median advantage of .23*d*. Males obtained higher Perceptual Reasoning IQs with a median advantage of .24*d*, and in Working Memory they had a median advantage of .24*d.* On Processing Speed females obtained higher IQs in 5 of the 7 studies with a median advantage of .32*d*.

The median male advantage of 3.6 IQ points on the WAIS Full Scale IQ in all 33 samples is a disconfirmation of the assertions by Halpern (2000, p. 91), Anderson (2004, p. 829) and Haier et al. (2004, p.1) that there is no sex difference on the WAIS Full Scale IQ. It is also a disconfirmation of Halpern's (2012, p. 115) assertion that in the standardization sample of the American WAIS IV "the overall IQ score does not show sex differences". Contrary to this assertion, Piffer's (2016) study shows that men obtained a statistically significant higher Full Scale IQ of 2.25 IQ points than women.

The median male advantage of 3.6 IQ points on the 33 studies of the WAIS

Full Scale IQ is only slightly lower than the male advantage of 4 IQ points among adults that I estimated in my first paper on this issue (Lynn, 1994). It should be noted that this male advantage is consistently present despite efforts by test developers to construct tests on which males and females obtain the same IQs. Thus “From the very beginning test developers of the best known intelligence scales (Binet, Terman, and Wechsler) took great care to counterbalance or eliminate from their final scale any items or subtests which empirically were found to result in a higher score for one sex over the other” (Matarazzo, 1972, p. 352); and “test developers have consistently tried to avoid gender bias during the test development phase” (Kaufman & Lichtenberger, 2002, p. 98). The Wechsler tests have reduced the true male advantage by excluding measures of spatial perception and mental rotation on which males obtain higher scores than females by 9.6 and 10.9 IQ points, respectively (Voyer, Voyer & Bryden, 1995); and also by excluding tests of mechanical abilities on which 18 year old males have an advantage of .72*d* (10.2 IQ points) (Hedges & Newell, 1995). This has been noted by Eysenck (1995, p. 128), who adopted my estimate of a 4 IQ point male advantage: “Allowing for the fact that Wechsler made every effort to equalize IQ between the sexes... we may perhaps say that an IQ difference of four points would be a conservative estimate of the true difference.”

8. Sex Differences in Verbal and Spatial Abilities

Ritchie (2015, p. 105) stated in his recent textbook on intelligence that “Women tend to do better than men on verbal measures, and men tend to outperform women on tests of spatial ability; these small differences balance out so that the average general score is the same.” A similar assertion has been made in a recent textbook on intelligence by Cooper (2015, p. 207), who writes: “In adulthood...women tend to perform better than men in verbal tasks, whilst men outperform women slightly in spatial tasks.”

Contrary to these assertions, scholars who have examined the evidence accumulated over many decades have concluded that there is virtually no sex difference in verbal abilities but there is a large male advantage in the spatial abilities. Half a century ago the evidence was reviewed by Tyler (1965, p. 144), who concluded that "on vocabulary, the sex groups have turned out not to differ significantly" but "in spatial relationships, a consistent male superiority has been demonstrated." Subsequent research has confirmed this conclusion. A meta-analysis of sex differences in verbal abilities by Hyde and Linn (1988) concluded that there is no sex difference although a weighted mean of all studies gave a male advantage of .04*d*. A meta-analysis of sex differences in spatial abilities by Linn and Petersen (1985) concluded that there is a male advantage of .50*d*. The average of the two meta-analyses gives a male advantage of .27*d* equivalent to 4.05 IQ points as predicted in the Introduction to this paper. A later study by Hedges and Newell (1995) reported the results of the American High School and Beyond data for 25,069 18-year-olds collected in 1980 showing that females had a negligible advantage of .04*d* on verbal ability and males had an advantage of .25*d* on spatial ability, giving an average male advantage of .19*d.* These results therefore do not support the assertions by Ritchie (2015) and Cooper (2015) that females obtain higher verbal IQs than males and males obtain higher spatial IQs than females and these balance out to give no sex difference in general intelligence.

9. Other Tests of General Intelligence

Sex differences in 26 studies of subjects aged 16 years and above using other tests of general intelligence are summarized in Table 7.

Table 7. *Sex differences in general intelligence (ds; positive signs denote males score higher).*

	Test	Country	N	Age	*d*	Reference
1	IUIS	USA	5748	17	0.15	Book, 1922
2	SB	USA	419	15-18	0.13	McNemar, 1942
3	AH4	Britain	4243	50-69	0.22	Rabbitt et al., 1995
4	AH4	Britain	900	50	0.08	Deary et al., 2001
5	AH4	Iran	3120	17-18	0.29	Mehryar et al., 1972
6	AH5	N. Ireland	1436	17	0.32	McEwen et al., 1986
7	IST	Germany	227	17	0.30	Amelang & Steinmayr, 2006
8	IST	Germany	207	34	0.40	Amelang & Steinmayr, 2006
9	IST	Germany	977	17	0.77	Steinmayr et al., 2015
10	IST	Austria	449	21	0.41	Pietschnig et al., 2011
11	Dureman	Norway	3064	18-65	0.51	Nystrom, 1983
12	DAT	Britain	653	17-18	0.12	Lynn, 1992
13	DAT	Ireland	2600	18	0.17	Lynn, 1996
14	DAT	Spain	703	16-18	0.21	Colom & Lynn, 2004
15	DAT	USA	692	16-17	0.12	Keith et al., 2011
16	Tiki-T	Indonesia	936	18-24	0.16	Drenth et al., 1977
17	SAT	Israel	1778	24	0.40	Zeidner, 1986
18	SAT	Sweden	31342	18	0.38	Stage, 1988
19	RIT	Portugal	1519	16	0.17	Lemos et al., 2013
20	Test QI	France	222000	21-70	0.25	Société Anxa, 2004
21	KAIT	USA	1146	17-94	0.22	Kaufman et al., 1995
22	KAIT	USA	1500	17-94	0.10	Kaufman & Horn, 1996
23	KBIT	USA	2022	4-90	0.16	Kaufman & Wang, 1992
24	WJIII	USA	441	19-79	0.57	Camarata & Woodcock, 2006
25	CET	USA	1394	16-20	0.14	Roalf et al., 2014
26	HCP	Netherlands	900	28	0.28	van der Linden et al., 2017

In all these studies males obtained higher IQs than females. There is a wide range of results from the male advantage of .08*d* to .77*d* with a median of .22*d.* Note that the male advantage of .15*d* among 17 year olds reported in 1922 and given in row 1 is virtually identical to that of .14*d* reported in 2014 for the same age group by Roalf et al. (2014) disconfirming the thesis advanced by Feingold (1988), Flynn (2012) and Mackintosh (2011) that a male advantage in former years had disappeared by the twenty-first century. The tests are identified in the Appendix.

10. Sex Differences in *g*

Spearman (1923) asserted that there is no sex difference in *g*, the common factor that accounts for about half the variance in intelligence assessed in tests like the Wechsler's, e.g. Colom et al. (2002). Studies that have addressed the question of whether there is a sex difference in *g* are summarized in Table 8. Row 1 gives the results of Jensen and Reynolds (1983) for the American WISC-R standardization sample of whites; a Schmid-Leiman principal factor analysis was carried out to obtain factor scores on *g* and on independent second stratum factors of verbal, performance and memory abilities. The first two of these correspond approximately to Carroll's second-stratum factors 2C and 2V; the third is more problematical and appears to be approximately Carroll's first stratum Perceptual Speed factor. The sex differences on the factor scores were calculated. The results were that males obtained a higher mean score on *g* of .161*d*, on the verbal and performance factors of .175*d* and .144*d,* while females obtained a higher mean score on the memory factor of .256*d*.

Jensen returned to this problem in his book *The g Factor* (1998, p. 538). Here he argued that his use of *g* factor scores in his first study was not the best method for analyzing sex differences in *g* because "*g* factor scores are not a pure measure of the *g* factor … it is somewhat contaminated by including small bits of other factors and test specificity measured by the various subtests." To overcome this problem he proposed the method of correlated vectors (CV), described as follows: "the sex difference in *g* is calculated by including the sex difference on each of the sub-tests of a battery in terms of a point-biserial correlation and including these correlations with the full matrix of inter-correlations for factor analysis; the results of the analysis will reveal the factor loading of sex on each of the factors that emerge from the analysis, including *g*" (Jensen, 1998, p. 538). His results for the WISC-R standardization sample are shown in Table 8. It will be seen that this method produced a similar but slightly greater male advantage of .189*d,* as compared with the male advantage of .161*d* obtained from the principal factor method shown in row 1.

Table 8. *Studies of sex differences in g (d, positive signs denote males higher).*

	Country	Age	N	Test	Method	*d*	Reference
1	USA	6-16	1868	WISC-R	PF	0.161	Jensen & Reynolds, 1983
2	USA	6-16	1868	WISC-R	CV	0.189	Jensen, 1998
3	USA	18-23	-	ASVAB	CV	0.366	Jensen, 1998
4	USA	25-34	-	WAIS	CV	0.012	Jensen, 1998
5	USA	18	-	GATB	CV	-0.527	Jensen, 1998
6	USA	17-17	-	BAS	CV	-0.002	Jensen, 1998
7	USA	18	2584	AFQT	CFA	0.06	Deary et al., 2007
8	USA	17-18	102516	SAT	CV	0.24	Jackson & Rushton, 2006
9	USA	18-79	436	Various	MIMIC	0.14	Johnson & Bouchard, 2007
10	USA	16	2100	KABC	MIMIC	-0.15	Reynolds et al., 2008
11	USA	17-18	275	KABC	MIMIC	-0.12	Reynolds et al., 2008
12	USA	16-59	3884	W-J III	MIMIC	0.08	Keith et al., 2008
13	USA	16-59	3086	W-J III	MIMIC	-0.17	Keith et al., 2008
14	USA-blacks	23	1383	ASVAB	PC	0.16	Meisenberg, 2009
15	USA-whites	23	3797	ASVAB	PC	0.45	Meisenberg, 2009
16	USA	16-89	2450	WAIS-III	MGCFA	0.20	Irwing, 2012
17	USA-blacks	16-17	472	ASVAB	PC	-0.30	Nyborg, 2015
18	USA-Hisp.	16-17	327	ASVAB	PC	0.04	Nyborg, 2015
19	USA-whites	16-17	913	ASVAB	PC	0.24	Nyborg, 2015
20	Denmark	11	52	Various	HOFA	0.18	Nyborg, 2005
21	Denmark	16	52	Various	HOFA	0.27	Nyborg, 2005
22	Germany	18-21	187110	TMS	PC	0.50	Stumpf & Jackson, 1994
23	Estonia	18	1201	Various	PC	0.65	Allik et al., 1999
24	Netherlands	Adults	519	WAIS-III	MGCFA	0.30	van der Sluis et al., 2006
25	Portugal	13	1714	RTB	MGCFA	0.13	Lemos et al., 2013
26	Portugal	16	1519	RTB	MGCFA	0.29	Lemos et al., 2013
27	Scotland	11	70000	CAT	PA	-0.01	Deary, Irwing et al., 2007
28	Spain	13	678	Various	PF	-0.19	Aluja-Fabregat et al., 2000
29	Spain	13	887	Various	PF	-0.15	Aluja-Fabregat et al., 2000
30	Spain	23	6879	Various	CV	0.49	Colom et al., 2000
31	Spain	23	3596	Various	CV	0.38	Colom et al., 2000
32	Spain	16-94	1369	WAIS-III	CV	0.16	Colom et al., 2002
33	Spain	16-34	588	WAIS-III	MGCMSA	0.03	Dolan et al., 2006

CFA: confirmatory factor analysis
CV: correlated vectors
HOFA: hierarchical oblique factor analysis (Schmid-Leiman transformation)
MGCFA: multi-group confirmatory factor model with mean structures
MGCMSA: multi-group covariance and mean structures analysis
MIMIC: multiple indicator-multiple cause
PA: principal axis
PC: principal components
PF: principal factor

Jensen (1998, p. 538) used the same method to analyze four further data sets. His results are summarized in rows 3-6. The results were that males obtained a higher *g* of .366*d* on the ASVAB (Armed Services Vocational Aptitudes Battery) and of .12*d* on the American standardization sample of the WAIS; females obtained a higher *g* of .527*d* on the GATB (General Aptitude Test Battery); while there was no sex difference (.002*d*) on the BAS (British Ability Scales). These results are highly inconsistent and Jensen (1998, p. 40) concluded that "the sex difference in psychometric *g* is either totally non-existent or is of uncertain direction and of inconsequential magnitude".

This conclusion cannot be accepted. The major inconsistency in these results is the large female advantage of .527*d* on the GATB. This is attributable, as Jensen points out (p. 543), to the presence in the battery of five perceptual motor tests on which females perform well. When these are removed and the analysis is carried out on the three cognitive tests of verbal, numerical and spatial abilities, the sex difference becomes .021*d* (a negligible difference in favor of males). This shows that the sex difference in *g* obtained by the method of correlated vectors depends on the nature of the tests from which the *g* factor is extracted and that the method of correlated vectors is flawed as a technique for measuring *g* independent of the nature of the tests in the battery from which it is extracted.

A number of criticisms of this method have been made by Dolan and Hamaker (2001), Lubke et al. (2003), Nyborg (2003) and Ashton and Lee (2005). These have argued that the method of correlated vectors is invalid on a number of grounds including (1) the correlations calculated using the method are dependent on the combination of subtests used to measure *g*; (2) the correlations between the sex and non-*g* sources of variance in the battery of tests; Ashton and Lee (2005) demonstrate that, due to these sources of contamination, the method of correlated vectors can yield a correlation of zero even when a variable has a strong relation with *g*, leading to the erroneous conclusion of no sex difference in *g*; (3) the method of correlated vectors lacks power even in large samples, because the degrees of freedom equal the number of subtests minus 1. Thus, the degrees of freedom were 4 and 5 in the two studies in the Colom et al. (2000) study, and 13 in the Colom et al. (2002) study, producing non-significant sex differences in *g* even though the differences are appreciable. This conclusion is elaborated by Nyborg (2003, p. 206), who also discusses the principal axis (PA) and principal components (PC) methods of measuring *g* and considers both unsatisfactory. He prefers hierarchical oblique factor analysis (HOFA, Schmid-Leiman transformation) on which he reported a male advantage on *g* of .27*d* in a sample of 16-year-olds.

Meisenberg (2009) reported that there was no significant sex difference on *g* among 15-year-olds among either blacks or whites. Among whites a significant male advantage of 4 IQ points was present among 16-year-olds, and this increased to an advantage of 6.5 points among 22-year-olds. For blacks there was a male advantage of 1 IQ point at age 16 that increased to an advantage of 2.15 points at age 22.

In more recent studies the preferred method for measuring differences in *g* has been the multi-group confirmatory factor model with mean structures (MGCFA) as described and used by Irwing (2012). Three studies have been published using this method for samples aged 16 and above with the results given in rows 16, 24 and 26 in Table 8, with male advantages of .20*d*, .30*d* and .29*d*. These give an average of .26*d*, almost the same as Nyborg's .27*d* estimate. This is equivalent to 3.9 IQ points, the same as my estimate of the adult male IQ advantage and thus suggesting that the male IQ advantage is wholly attributable to an advantage in *g*. We have therefore reached the opposite of Jensen's (1998, p. 540) conclusion that "the sex difference in psychometric *g* is either totally non-existent or is of uncertain direction and of inconsequential magnitude; the generally observed sex difference in variability of tests scores is attributable to factors other than *g*", and also contrary to the conclusion reached by Colom et al. (2000, p. 65) that there is "a negligible sex difference in *g*."

A further method for estimating the sex difference in *g* is to adopt the Raven's Progressive Matrices as a proxy for *g* as proposed by Mackintosh (1996) and Jensen (1998, p.38) because its *g* loading is approximately .80. As noted in Section 3, the meta-analysis of the sex difference among adults showed a higher male average of .33*d* (Lynn & Irwing, 2004) giving a further confirmation of a male advantage in *g*.

11. Sex Differences in High Achievement

It is a notorious fact that there are many more men than women at the top of all professions, except of course the oldest. This has frequently been attributed to "the glass ceiling", an invisible and hypothetical barrier that men in senior positions impose to prevent women from rising to the top. Ceci and Williams (2007) have edited a book in which 15 experts discuss this phenomenon in connection with the question of why there are so many more men than women who are high achievers in science. None of these experts described as "top researchers" acknowledge that this is partly attributable to men having a higher average IQ than women and hence a greater proportion at the high end of the IQ distribution. Two of these experts, Spelke and Grace (2007), mention this as a possibility but dismiss it citing evidence that there are no sex differences in ability among infants on the basis of which they assert that "men and women have equal cognitive capacity" (p. 65).

None of the 15 experts discuss the explanation advanced by Eysenck (1995, p. 128) for the larger numbers of men than of women at the top of science and other professions and among geniuses. Eysenck accepted my thesis that men have a 4 points higher IQ than women and calculated that this advantage combined with the greater male variance of a standard deviation of 15 for men and 14 for women would produce 55 men and 5 women per 10,000 with an IQ of 160 and above, a ratio of 10:1. The same point has been made more recently by Nyborg (2015, p. 51), who presents data for a male advantage of 3.9 IQ points among American white 17 year olds and calculates that this advantage gives men a ratio of 5:1 to women at an IQ of 145 (approximately one per 300 males). He shows that this is about the ratio of men to women in senior positions in academia and business in a number of countries. In addition to the IQ advantage, it has been shown in a number of countries that men are more competitive than women and hence more motivated to reach top positions (Lynn, 1993). The higher average male IQ, greater male IQ variance and greater male competitiveness are sufficient to explain the greater numbers of men than of women in top positions. The construct of a glass ceiling barrier calls for William of Ockham's (1281-1347) razor: "Hypothetical entities should not be unnecessarily multiplied".

12. The Pietschnig, Penke, Wicherts et al. (2015) Study

The recent meta-analysis of the relation between brain size and intelligence by Pietschnig et al. (2015) makes an important contribution to the sex differences paradox. The study confirms the positive association and concludes from an analysis of 88 studies that the correlation is .24. Pietschnig et al. (2015) acknowledge their result may imply that males should have a higher average IQ but state that "careful analyses of datasets not limited by range restriction clearly indicate the absence of sex differences in IQ (Dykiert, Gale & Deary, 2009; Flynn, 2012; Johnson, Carothers & Deary, 2009)".

The three citations in the last of these papers do not support the authors' assertion that there is no sex difference in IQ. The paper by Dykiert, Gale & Deary (2009) showed that in 10 year olds tested in the 1970 British Cohort Study boys had a significantly higher IQ of .081*d.* In a subsequent follow up at age 26 the attrition rate was 43% and was greater for males and the male advantage had increased to .124*d.* The authors conclude that "a proportion of the apparent male advantage in general cognitive ability reported by some researchers might be attributable to the combination of greater male variance and sample restriction..." (p. 42). All this paper showed was that in longitudinal studies the follow-up samples are no longer representative because of attrition and cannot be relied on to give accurate data on sex differences. In no way does it support the assertion that it "clearly indicates the absence of sex differences in IQ." The authors' citation of Flynn (2012) refers to a study of young adults in Argentina in which there was no sex difference on the Progressive Matrices, but the authors chose to ignore the meta-analysis of sex differences on the Progressive Matrices in general population samples that gave the results of ten studies of adults in all of which males obtained higher scores with an average advantage of 0.33*d* equivalent to 5 IQ points (Lynn & Irwing, 2004). The authors' third citation (Johnson, Carothers & Deary, 2009) gives the results of two studies of 10-12 year olds in which there was no sex difference in IQ. They do not acknowledge my theory that the male advantage only appears from the age of 16 years or the large number of studies supporting this theory. They conclude that males and females have the same IQ and "thus large brains and neuron numbers do not need to translate into higher intelligence among humans", but they do not offer any explanation for this exception to the numerous studies showing a positive association between brain size and intelligence.

13. Evolutionary Psychology of the Higher Male IQ

We turn now to the evolutionary explanations of the higher male IQ. There are three problems that require consideration: (1) why males have evolved greater spatial abilities; (2) why males have evolved greater reasoning abilities; and (3) why females mature more rapidly than males. The likely explanation of the evolution of greater spatial abilities of males is that during the last several million years hominids became hunter-gatherers in which males specialized in hunting and females specialized in gathering plant foods (Lovejoy, 1981; Watson and Kimura, 1991). Hunting large animals requires spatial abilities to enable males to throw stones and spears accurately, at which males are better than females (Watson & Kimura, 1991), to plan group hunting strategies such as driving potential prey into the loops of rivers, and to make weapons such as spears and bows and arrows with which to kill prey. Females had less need for spatial abilities and so did not evolve them so strongly. The female specialization of gathering plant foods is less cognitively demanding.

The likely evolutionary explanation of the greater reasoning ability of males is that in most mammalian group-living species males compete for high status in dominance hierarchies in order to secure access to females and reproduction (Wilson, 1975; Wynne-Edwards, 1962). During the evolution of the hominids greater reasoning ability would have contributed to success in this intra-male competition enabling males with greater intelligence to form useful alliances, display leadership qualities in hunting and warfare, and out-talk other males with lesser intelligence. This advantage is present in contemporary societies where intelligence is a significant determinant of rank indexed by socio-economic status with which it is correlated at 0.46 (Jencks, 1972).

The likely evolutionary explanation of the more rapid maturation of females is that it is advantageous for them to begin reproducing in puberty as soon as they are sufficiently mature to have babies and look after them. It is advantageous for males to continue maturing beyond the age of 16 years because it takes longer for them to acquire the experience and skills required to work their way up the dominance hierarchies and obtain sufficient status to secure access to females.

14. Conclusion

I began this paper by stating the problem of the inconsistency between the assertions of numerous experts that "females and males score identically on IQ tests" (Halpern, 2012, p. 233) and the theoretical expectation that the larger average brain size of males should give them a higher average IQ than females. I presented as a solution to this problem the developmental theory of sex differences in intelligence stating that boys and girls have about the same IQ up to the age of 15 years but from the age of 16 the average IQ of males becomes higher than that of females with an advantage increasing to approximately 4 IQ points in adulthood. The magnitude of the adult male advantage cannot be precisely quantified and will vary according to the definition of intelligence but whatever definition is adopted the data reviewed in this paper show that among adults men do have a higher average IQ than women. Thus the theoretical expectation that males should have a higher average IQ than females is correct for adults. As Einstein is said to have observed, "When the data and the theory are in conflict, it is generally the data that are wrong."

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Appendix

Description of the tests given in Table 7:

AH4 and AH5: These tests consist of two parts designated verbal-numerical and diagrammatic (consisting of spatial and non-verbal reasoning). These are summed to give a total representing general intelligence (Heim, 1968).

CET: The Conditional Exclusion Test of a number of mental abilities. The data shown are for the Abstraction and Mental Flexibility test.

DAT: The Differential Ability Test contains 8 tests covering verbal, reasoning, spatial, memory and perceptual speed averaged to give an IQ. Keith et al. (2011) aggregate these from the American standardization sample into four ability factors identified as visual memory (Gv), free recall memory (Gfr), working memory (Gwm) and perceptual speed (Gs) and give the average of these as a male advantage of .12*d*.

Dureman-Salde: A Norwegian test of verbal (.047*d*), reasoning (.77*d*) and spatial (.770*d)* abilities averaged to give general intelligence. Male advantages are given in parentheses. Note the marginally higher male verbal ability and much higher male spatial ability confirming the Wechsler results and contrary to assertions of Cooper (2015) and Ritchie (2015) that higher female verbal ability and higher male spatial ability balance out to produce no difference in general intelligence.

IST: Intelligenz-Struktur-Test. A German test of general intelligence measuring a number of abilities that are averaged to give an IQ.

KAIT: Kaufman Adult Intelligence Test. A test of general intelligence measuring a number of abilities that are averaged to give crystallized and fluid IQs. There were higher male IQs on these of 0.7 and 2.3 IQ points, respectively, and are averaged to 1.5 equivalent to .10*d* given in Table 7.

KBIT: Kaufman Brief Intelligence Test. A short form of the KAIT.

RIT: A Portuguese test of general intelligence.

SAT: Scholastic Aptitude Test (Sweden) consists of verbal (.04*d*), reasoning (.54*d*) and spatial (.56*d*) abilities averaged to give general intelligence. Male advantages are given in parentheses. Note the marginally higher male verbal ability and much higher male spatial ability confirming the Wechsler results and contrary to assertions of Cooper (2015) and Ritchie (2015) that higher female verbal ability and higher male spatial ability balance out to produce no difference in general intelligence.

SAT: Scholastic Aptitude Test (United States) consists of verbal and mathematical abilities taken for entry to university.

SB: Stanford-Binet. A test of general intelligence.

Test de QI: A French test of general intelligence administered over the internet.

Tiki-T: An Indonesian test of verbal (.11*d*), reasoning (.15*d*) and spatial (.29*d*) abilities averaged to give general intelligence. Male advantages are given in parentheses. Note that the sex differences on the three abilities are similar to those in western countries with the greatest male advantage in spatial ability and the least in verbal ability.

WJ III: The Woodcock-Johnson Test of general intelligence measuring a number of abilities including fluid IQ given in Table 7.

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Male and Female Balance Sheet

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This paper isolates gender differences in IQ that refer to the current generation of women in developed nations and where samples appear large and representative. At no age do such women begin an IQ decline vis-à-vis males. They suffer from a spatial deficit that might dictate fewer of them in "mapping jobs". Against a male average of 100, they have a fluid intelligence of 100 (university Raven's data) to 100.5 (Raven's data from five modern nations); and a crystallized intelligence of 97.26 (WAIS data plus non-Wechsler IQ) to 100 (non-Wechsler GQ).

No matter whether we take the lower values or a mean value, we would expect females to match males on mathematics and do no better than males at school. Both expectations are false. If there are genetic differences between men and women, these have more to do with character than intellect. First, women tend to be less violent and combative than men. Compared to schoolgirls, boys hand in assignments late, miss school more often, drop out more often, and must be disciplined more often. Second, women from infancy are more sensitive to other human beings. The ratio of women falls from dominant to rare as we go from social science to medicine and biology, to chemistry, to math and physics. There are two ways of viewing this progression: either women value math less insofar as it has no immediate human application; or women are deterred by the fact that math gets more difficult as you go from psychology to mathematics. Since either of these traits could be genetic in origin, I can see no easy way of obtaining conclusive evidence one way or the other.

Key Words: Sex differences, Intelligence, Raven test, Wechsler test

Once again we owe a debt to Richard Lynn for assembling exhaustive data on male versus female differences on IQ tests. I wish to compliment him for addressing a subject that many ignore because they put a quiet life ahead of truth. As for his data, I want to make certain distinctions: between fluid intelligence and crystallized intelligence; between the role of genes and environment; and between the influence of intellect and character on cognitive achievement. Lynn does not discuss genes directly but he gives the kind of evolutionary scenario that implies differential selection between the sexes for personal traits.

The Ravens' data

Lynn has offered a huge amount of data from Raven's Progressive Matrices, and I have analyzed it and added supplementary material in my book, *Are We Getting Smarter* (2012, pp. 141-157). Lynn's interpretation is plausible if you merge all Raven's studies. But that means lumping the current generation of women with past generations, large and representative samples with convenience samples, and non-elite samples with elite samples composed of university students. With this in mind, I isolated Raven's data from six advanced nations in which women have (usually) enjoyed the effects of modernity, and which allow us to compare females with males both below and above the age of 14. Other criteria: the data must be recent and of high quality, for example large standardization samples.

Although the university samples are elite, they are so numerous and international that I believe they tell us something about university students in general at least in advanced nations. Paradoxically, I argue that the fact that university females have a lower mean IQ than males is evidence for genetic parity rather than male superiority.

University samples

Gender parity hypothesis: In the general population of 17 to 22 year olds, we will assume that males and females are equal: they have the same mean IQ (100) and standard deviation (SD) (15). An SD of 15 is the usual value when you include the whole population but lower values hold for non-representative groups. For example, university students include only the higher IQ scores and the measure of this reduction in range is that they would have an SD well below 15.

Let us also assume that women can qualify for university with a lower IQ than men, say that the university IQ threshold for males is 100 and for females 95. If so, male university students would have a mean IQ of 111.97 (the bottom half of the IQ curve is gone) and a standard deviation of 9.04 (the missing half reduces the full curve's SD). Females would have a mean of 108.99 (the bottom 37 percent of the curve gone) and an SD of 9.97 (less than half of their curve is gone). The male mean would be 2.98 points higher (111.97 – 108.99); and the female SD would be 110 percent of the male (9.97 divided by 9.04).

To elaborate: if the university population is drawn from the upper 50 percent of males and the upper 63 percent of females, then of course the male sample is more elite and will have a higher mean IQ. And if the university population contains a larger portion of the full female IQ curve than the male, then of course the female sample is more complete and will come closer to their population SD than the male sample will.

Male superiority hypothesis: In the general population, males have a mean IQ of 100, females a mean of 95, and both an SD of 15. The university IQ threshold for males and females is the same at 100. If so, male university students would still have a mean of 111.97 and an SD of 9.04. Females would have a mean of 110.30. The bottom 63 percent of the curve gone would raise the mean of the remainder by 1.02 SDs (1.02 x 15 = 15.30, which plus 95 = 110.30). Females would have an SD of 8.18 (with the bottom 63 percent gone). Therefore, the male mean would be 1.67 points higher (111.97 - 110.30); and the female SD would be just over 90 percent of the male SD (8.18 divided by 9.04).

The interesting thing is that the male superiority hypothesis predicts a male IQ advantage (among university students) slightly *smaller* than that predicted by the gender parity hypothesis! Everyone can see the effect of the male superiority hypothesis on SDs: the SD of university females would have to be *lower* than that of males (the upper half of males can get into university, but only the upper 37 percent of females). The equality hypothesis clearly predicts the opposite: a *higher* SD for university women. So keep your eye on the SDs.

What does the Raven's data say?

I reviewed the university data collected by Irwing and Lynn (2005). My thesis of gender parity applies to the current generation in nations or groups where women enjoy modernity. Therefore, I set aside university data from 1964 to 1986 (in favor of that from 1998 to 2004), data from developing nations, and one set which did not specify the nature of the Raven's test. The remaining data cover 6230 subjects.

Box 1 shows that the results confirm the gender parity hypothesis: males have an IQ advantage of 2.73 points (predicted 2.98); the female SD is 106 percent of the male (predicted 110). I suspect that the latter shortfall is because females do not quite have SD parity in the general population. Mathematics and science have a robust correlation with Raven's. Ceci and Williams (2010) found that while there was no difference between the genders at the mean on these tests, the male SD was larger. Lynn seems to concede this point. He cites Eysenck who puts the female SD at 14 in the general population, a value a bit below where we would put it today.

Box 1 (for details, see Table AIV1 in Appendix IV of Flynn, 2012)
There are nine recent university samples with adequate data. In each SD at 14 in the general population, a value a bit below where we would put it today.case, I give the nation, the date, the male advantage in IQ points, and the percentage you get when you divide the female SD by the male SD. Where the female SD is larger, it equals more than 100 percent of the male SD; where smaller, it equals less than 100 percent.

Canada (1998)	2.45 IQ points – 105%
Canada (2000)	4.34 IQ points – 104%
South Africa (2000)	2.19 IQ points – 82%
Spain (2002)	2.81 IQ points – 110%
Spain (2004)	2.47 IQ points – 102%
Spain (2004)	2.72 IQ points – 109%
USA (1998)	4.44 IQ points – 119%
USA (2004)	2.13 IQ points – 97%
USA (2004)	2.93 IQ points – 110%
Average:	2.94 IQ points – 104%
Weighted Average:	**2.73 IQ points – 106%**

You get a perfect fit for the university data if you posit the following values for the general population: the genders equal for mean IQ at 100; the female SD at 14.62, slightly lower than male at 15; a female IQ threshold for university at 96, that is, 4 points lower than the male at 100. The university results are far from those predicted by the male advantage hypothesis: a 1.67-point male advantage and a female SD at only 90 percent of male. Once again, the true values are 2.73 and a female SD at 106 percent.

The fact that the within–university female SD is so much larger than the male is devastating. How could the female SD soar above the male SD among university students except due to a lower IQ threshold, one that allowed a larger proportion of females into university? In fact, if you assume a common IQ threshold for male and female university students, it is impossible to explain both the male IQ advantage and the larger SD for females we find in the university data (Flynn, 2012, Appendix IV).

Students in general

I have not yet provided direct evidence for the hypothesis that females enter university with a lower IQ threshold than males. Between 1990 and 2000, female high school graduates in America had a Grade Point Average (GPA) well above boys (Coates & Draves, 2006). Gurian (2001) estimates that boys get 70 percent of the Ds and Fs and girls get 60 percent of the As. About 80 percent of high school dropouts are boys. Coates and Draves find a similar pattern in the United Kingdom, Ireland, Scandinavia, Australia, New Zealand, and Canada. No advanced nation has as yet been found to be an exception.

The Organization for Economic Co-operation and Development (OECD) published the results for 15-year olds on a test of reading proficiency (PISA, 2006). In every one of the 57 nations, high school girls outperformed boys. The merged results suggest that the female IQ threshold for university entrance is about 3 points below the male threshold, and that the mean IQ of female university students is about 2 points below males. US data were not available from the OECD. However, the Nation's Report Card shows that the median for girls' reading proficiency was at the 67th percentile of the boys' curve (Grigg et al., 2003). This means that the US gender gap is a bit high but comparable to nations like Austria, Belgium, Germany, Italy, Norway, and Sweden.

It should be noted that males do marginally better than females for mathematics (PISA, 2006, Table 6.2c). I assume that reading and good grades bolster confidence to go to university; and that lacking mathematics proficiency discourages few students. Rather they choose a non-science major. The Nation's Report Card also shows that American girls open up an even greater gap for written composition: their median was at the 75th percentile of the boys' curve.

I will state what I think a judicious conclusion: unless different gender IQ thresholds are falsified, university samples suggest parity. It can easily be tested. Get a sample of the entering class, and test to see whether men begin to disappear at an IQ level say 4 points above where women begin to disappear.

Current standardization data from six nations

Five nations offer current data from standardization samples. In Argentina, the Universidad Nacional of La Plata standardized Raven's between 1996 and 2000 on 1695 students. They ranged from 13 to 30 years of age. The sample was designed to simulate a random sample of the city's in-school population

(Rossi-Casé, 2000). Standardization samples tested in 1984 and 1986 afford data from New Zealand and Australia (de Lemos, 1988; Reid & Gilmore, 1988). The South African data are from Lynn (2002), who reports the results Owen (1992) got when he derived South African norms for Raven's by tests administered between 1985 and 1988. Thus, some samples are from the mid- to late-1980s but they are the latest I could find. In 2000, Raven's was standardized in 27 Estonian-speaking schools (Lynn et al., 2004) on students aged 12-18 (1250 males and 1441 females).

The Estonian samples for ages 16 to 18 show radically reduced SDs thanks to the elite character of those tested at those ages (the academic stream). Using a proper value for Raven's SD, the results as presented showed that males aged 16-18 outscored females by 1.05 IQ points. I perceived that this was because the age samples were flawed; for example, they consistently omitted girls who were progressing faster through school (the brightest) and compared them to boys who were more representative. They even showed girls aged 13 with a lower Raven's raw score than those aged 12, something that could not be true of the general population. I isolated the main sources of bias and devised corrections (Flynn, 2012, Box 34 & pp. 272-283). These had a profound effect on Estonian gender comparisons.

In all nations where data were drawn from schools, I had to adjust for the fact that more males than females are school dropouts, which eliminates a low-scoring group from the male sample. These adjustments were minor (about 0.4 points).

Table 1 gives summary results for these five nations. Almost all show a slight IQ advantage for females (Australia suggests parity) and none show a fall off with age, particularly when the suspect value from Estonia at age 12 is discarded. The values for the older subjects from Argentina could not be adjusted for a higher male dropout rate because, at those ages, factors other than academic failure affect the percentage of those in the in-school population.

Lynn (1994, 1999; also Lynn & Irwing, 2004) has been consistent in naming 15 as the age at which males forge ahead, but this does not debar a hypothesis that the age of onset is 16 or 17. This would render inconclusive all data except those from Argentina and Estonia. But even two nations put a heavy burden on any hypothesis that women have inferior genes for fluid intelligence. It is possible that these two nations foster a cognitive environment that favors women over men, but the supporting evidence would have to go far beyond Raven's scores. In addition, age 17 divides high school from university. The overwhelming drift of the university data shows that this age does not mark the beginning of a female decline.

Table 1. *Raven's: Female IQs (male set at 100) from five nations by age.*

Nation	Ages										
	12	13	14	15	16	17	18	19	20-24	25-29	30
Estonia	(106.4)[1]	103.1	100.8	103.1	100.4	100.1	100.8				
Argentina		100.1				100.8*			100.4	100.1+	100.3+
South Africa				100.8							
New Zealand				101.4+							
Australia				99.99**							
Average	**(106.4)**	**101.6**	**100.5**	**100.9**		**100.5**	**100.8**	**100.8**	**100.4**	**100.1+**	**100.3+**

[1] The bracketed value for age 12 in Estonia cannot be valid. It is based on a raw score for girls at that age that is higher than their raw score at age 13.

+ These values could not be adjusted against census data to compensate for a possible heavier male dropout rate.

* Census data forced me to merge some Argentine ages when making adjustments (e.g. it covered ages 15-19 en bloc). However, there is no fiddle here: unadjusted score differences between male and female were virtually uniform over all ages from 15 to 19.

** The value for ages 15-16 for Australia is the average of a timed and untimed administration of the test. All other administrations were untimed.

Note that I qualify my conclusion by restricting it to societies that allow women full modernity. The South African data above is for whites only, but the same source gives results for women that are less modernized. Assuming gender parity for whites in South Africa (set at 100), Indian women were at 96, Coloured women at 97, and Black women at 95.

I have also studied a sixth "modern" nation where we have reliable data. Israel is an exception that proves the rule. Flynn (1998) reports military data from Israel for 17-year olds who took a shortened version of Raven's from 1976 to 1984. Men outscored women by the equivalent of 1.4 IQ points. The female deficit is entirely due to the fact that about 20 percent of the women were primarily from Orthodox homes, usually of Eastern European origin. They had a mean IQ of about 90.6, about 10 points below the mainstream of Israeli women. The women were either married at age 17 and a half, or were wards of their fathers until passed on to their husbands. Unlike men, Orthodox women are forbidden to read the Torah, much less participate in debates about its meaning.

These data are from the 1980's. Here I wish to compare data on crystallized intelligence among school children (age 6-16). Lieblich (1985; no. = 2111) reports WISC-R Performance IQs (closest to Raven's) that show Jewish girls with a 2.85 IQ point deficit — close to the total sample of 17-year-olds that had a 1.40-point deficit on Raven's. However, Cahan (2005; no. = 1100) reports a nil deficit (actually it was 0.15 points). The deficits for Full Scale IQ are more worrying at 4.80 (1985) and 2.85 (2005) points. Does Israel still have a huge minority of women that it denies modernity? I am aware that the Orthodox would say that this is indeed their objective and that it preserves their very identity. Whatever the merit of their spiritual success, Israel may pay a heavy price in the unrealized potential of so many of its women.

Lynn's recent Raven's data

Lynn does not alter his conclusions based on his total Raven's data, which were that from the age of 16 on, women begin to show an IQ deficit of 5 points (general population) and 4.6 points (in university). He adds two new studies.

In 2013, 136 Jewish adults (62 women and 74 men) from Serbia took Raven's. The female disadvantage was 4.05 IQ points (Čvorović & Lynn, 2014). The 2011 Serbian census shows 1185 Jews of whom 787 declared themselves as Jewish while others declared their religion as Judaism. The sample is from the remnants of a community destroyed by the Holocaust and further decimated by migration. Of course, it is not a Serbian sample (population 7.5 million). Whether they are even representative of adult Serbian Jews is unclear: the local Rabbi (there is only one Synagogue left in Serbia) and personal contacts recruited them. They are rather like a convenience sample from a Synagogue in Washington D.C. However, the fact that their average age was 54.5 years bars them from tracing a female deficit that begins at the age of 16.

Lynn cites Deary et al. (2004) as evidence for a 4.35-point female deficit on Raven's using the Lothian cohorts (samples representative of Scotland). When the 1921 cohort was tested at about age 80, males had a 1.5 raw score advantage. The SD of 8.8 was somewhat attenuated and I have put it at 10 for the total population, giving a male advantage of 2.25 IQ points. When the 1936 cohort was tested at about age 65, men had a 0.9 raw score advantage and thus an IQ advantage of 1.35 points. However, quibbling over the size of the female deficit is irrelevant. Once again, the advanced age of the subjects forbids any conclusions about the onset of a Raven's deficit. More important, all of these subjects were born at a time well before the generation in which Scottish women can be said to have achieved modernity.

The Wechsler data

I have used the same method with Lynn's Wechsler data. This meant:

(1) Jettisoning nations like China, Japan, Bahrain, Iran, Israel, Mauritius, Sudan, Taiwan, and South Korea as cases in which women may not have achieved modernity. If any object to this, construe my conclusion as applying to women outside of Asia and Africa. I have also separated Italy out for special treatment. Including it in the adult data would only raise the male advantage for Full Scale IQ by 0.4 points. But having read the Neapolitan novels (Ferrante, 2012, 2013, 2014, 2015) and surfed the internet ("current status of women in Italy"), I felt I had to stress the fact that Italy's male advantage is three times that of my other adult data collectively.

(2) Jettisoning all data prior to the WPPSI, WISC-R, and WAIS-R as clearly applying to an earlier generation. The WPPSI (normed 1964.5) sneaks in because of the youth of its cohorts. Those aged 4-7 would also be included in the WAIS-IV cohorts; that is those aged 46-49 in 2007. When I compare Italians on the WISC-IV (as children) with those on the WAIS-R (as adults), it might seem that the latter are from an earlier era. In fact, the WAIS-R was normed in Italy only in 1996 (Orsini & Laicardi, 1997).

(3) Jettisoning small convenience samples in favor of large samples, preferably standardization samples. The WPPSI data and most of the WAIS-III and WAIS-IV data are from standardization samples. None of the other data sets selected numbers less than 519 with the exception of Finland (407), a careful study done by the Psychological Corporation itself. I eliminated the WISC-R data from Knopic and DeFries (1998), despite a size of 852, because the sample was drawn from twins who served as control participants in the Colorado Learning Disabilities Research Center.

Results

In Table 2, I present my results study by study for Full Scale IQ, Verbal IQ, and Performance IQ. The most recent Wechsler tests eschew the Verbal and Performance categories in favor of four Index scores for Verbal Comprehension, Working Memory, Perceptual Reasoning, and Processing Speed. To get comparable values with earlier tests, I have averaged the first two to get a Verbal score and the second two to get a Performance score. This maintains continuity as much as possible in terms of subtests. In Table 3, I organize my results by age expressed in conventional IQ scores and do the same for Italy.

Table 2. *Wechsler tests: Male (plus) and Females (minus) advantages by test for Full Scale (FS), Verbal (V), and Performance (P) IQs expressed in Standard Deviation Units.*

Nation	Test	N	FS	V	P	Reference
USA	WPPSI	1199	-0.06	-0.02	-0.01	Kaiser & Reynolds, 1985
	WPPSI average		-0.06	-0.02	-0.01	
	IQ point average		**-0.90**	**-0.30**	**-0.15**	
Belgium	WISC-R	761	0.12	0.16	0.10	van der Sluis et al., 2008
Germany	WISC-IV	1650	0.07	0.19	0.00	Goldbeck et al., 2010
Germany	WISC-IV	1650	0.06	0.135	-0.10	Goldbeck et al., 2010
Netherlands	WISC-R	2027	0.14	0.16	0.08	Born & Lynn, 1994
Netherlands	WISC-R	737	0.25	0.26	0.00	van der Sluis et al., 2008
New Zealand	WISC-R	897	0.06	0.09	0.00	Lynn et al., 2005
Scotland	WISC-R	1361	0.18	0.31	0.01	Lynn & Mulhern, 1991
USA	WISC-R	1868	0.12	0.19	0.01	Jensen & Reynolds, 1983
USA	WISC-III	2200	0.11	0.095	-0.19	Irwing & Lynn, 2005
	WISC average		0.123	0.177	-0.01	
	IQ point average		**1.85**	**2.65**	**-0.15**	
Brazil	WAIS-III	3494	0.07			Victora et al., 2015
Canada	WAIS-III	1104	0.11			Longman et al., 2007
Chile	WAIS-IV	887	0.20	0.205	0.145	Diaz & Lynn, 2016
Finland	WAIS-III	407	0.07	0.08	0.07	Finland Psych. Corp., 2006
Hungary	WAIS-IV	1110	0.08	0.175	-0.07	Rózsa et al., 2010
Netherlands	WAIS-III	519	0.24	0.28	-0.11	van der Sluis et al., 2006
Spain	WAIS-III	1369	0.24	0.185	0.210	Colom et al., 2002
USA	WAIS-R	1880	0.15	0.15	0.09	Matarazzo et al., 1986
USA	WAIS-III	2450	0.18	0.235	-0.115	Irwing, 2012
USA	WAIS-IV	2200	0.15	0.225	-0.03	Piffer, 2016
	WAIS average		0.15	0.15	0.024	
	IQ point average		**2.24**	**2.30**	**0.36**	

Table 3. *Female IQs (male set at 100) for current generation in advanced nations, Wechsler data from Table 2 sorted by age*

Ages	Full Scale	Verbal	Performance
		Without Italy	
4-7	100.0	100.30	100.15
6-16	98.15	97.35	100.15
17-90	97.76	97.70	99.65
		Italy	
6-16	100.45	99.25	101.80
17-74	93.35	93.74	94.86

Analysis

The WPPSI data is sparse but taking it at face value, it shows that in America, the roles assigned female and male preschoolers do not differentiate them for IQ test performance. Taking all ages, the first thing to notice is that the genders are essentially equal for Performance IQ throughout life. This is similar to Raven's IQ and adds confirmation to gender parity on that test. The second is that while women are about two IQ points behind for Full Scale IQ both as schoolchildren and adults, there is no reason to single out age 16 or 17 as significant. Even if one takes the 0.39-point loss from WISC to WAIS seriously, it could set in at any age: my best bet would be when women begin to bear disproportionate responsibility for child rearing. However, Full Scale IQ masks a female Verbal IQ deficit of about 2.5 points throughout life. This is surprising given that women perform better at both school and university, and we shall return to it. As for Italy, women go from parity with the current generation of other advanced nations at school to a profound deficit on all three kinds of IQ as adults. Perhaps Italian women, like Orthodox women in Israel, are denied modernity to a degree extraordinary in nations of European origin.

The general intelligence data

In screening this data, I had to relax my criteria or there would be little left, but this means that the results must be taken as tentative. I have jettisoned Asian samples (Iran, Indonesia, and Israel), small convenience samples, and studies whose subjects belonged to an earlier generation. Stage (1988) just qualifies. A large sample of Swedish subjects took something like the Scholastic Aptitude Test in 1984-1986. Since these were students aspiring to university, its inclusion is marginal. Its gender deficit of 0.37 SDs (as reported) is calculated subtest by subtest using the in-sample SD. Two biases work in opposite directions: population SDs would be larger and lower the estimates; but if males do better on almost all subtests their overall advantage would be greater. I will simply assume that these cancel out. Nystrom (1983) was excluded because the sample was selected (in Stockholm) in 1970.

I have omitted Steinmayr et al. (2015), which shows a huge gender difference with females at a deficit of 0.78 SDs (as reported). Its subjects took not a general intelligence test but a general knowledge test: Geography (identifying African countries), History (when was the French revolution), Economics (what factor is not part of the GNP), Science (how many planets have rings), mathematics (what does the symbol ∞ mean – it is the symbol for infinity), arts (which picture was not painted by Picasso), and daily life (which means of transport has the lowest accident rate). It is interesting that the authors applied a screen for gender bias that lowered the female deficit to 0.32 SDs.

Pietschnig, Voracek and Formann (2011) tested psychology students at the University of Vienna. They were overwhelmingly female (326 to 123), so his sample poses problems even more serious than normal university samples. It is a study of IQ gains over time, and all students were scored on items common to an edition normed in 1970 and an edition normed in 2000. Against the older norms, the female deficit was 0.51 SDs; against the current norms, it was down to 0.32 SDs for no reason I can imagine. These are within-sample SDs and therefore attenuated. If you use a population SD of 15, the deficits drop to 0.37 (5.60 IQ points) and 0.23 (3.40 IQ points) respectively.

The remaining studies have large numbers and are current. Some are convenience samples, some likely to be representative, some standardization samples. Van der Linden and Dunkel (2016) is still under submission and I take it on faith. There are eight studies that span ages 16-21; as Lynn says, they range widely and therefore, I follow him by using the median rather than the mean.

Results

It is not easy to construct an age profile from these data but Table 4 makes an effort. Massive data for early adulthood (ages 16-21) show a female IQ deficit of 2.55 points. When sporadic data by age is averaged, the deficit is 2.81 points for all adult years (16-69) and when this is averaged with studies that include adults of all ages, the deficit is 2.84 points or virtually the same. There is one study that included all ages beginning with pre-school that gives 2.4 points.

Table 4. *Female IQs (male = 100) by age based on 14 tests of general intelligence.*

Ages	Female IQ	N	Studies and female deficit in SDs
Median 16-21	**97.45**	40,342	McEwan et al., 1986 (0.32); Lynn, 1992 (0.12); Lynn, 1996 (0.17); Colom & Lynn, 2004 (0.21); Keith et al., 2011 (0.12); Stage, 1988 (0.38); Lemos et al., 2013 (0.17); Roalf et al., 2014 (0.14). Median = 0.17.
28	95.80	900	van der Linden & Dunkel, 2016
56	98.80	900	Deary et al., 2001 (.08)
50-69	96.70	4243	Rabbitt et al., 1995 (0.22)
Average 16-69	**97.19***		
21-70	96.25	22,200	Société Anxa, 2004 (0.25)
17-94	96.70	1146	Kaufman et al., 1995 (0.22)
17-94	98.50	1500	Kaufman & Horn, 1996 (0.10)
Average 16-94	**97.16****		
4-90	**97.60**	2022	Kaufman & Wang, 1992 (0.16)

* The four values for ages 16-21, 28, 56, and 50-69 were averaged.
** The values for ages 16-69, 21-70, 17-94, and 17-94 were averaged.

Analysis

These results are so close to the Wechsler results as to make no difference: 97.16 as compared to WAIS Full Scale IQ at 97.76. The 97.24 for ages 16-25 is so close to the 97.16 for all adult ages as to signal no watershed year in late adolescence at which female IQ begins to decline. There is nothing that would give us a value for either preschoolers or schoolchildren analogous to the WPPSI or WISC results. If you take the data that covers all ages from 4 to 90, and set age 4 to 7 at gender parity, you get 97.48 for ages 8 to 90. This is quite plausible but tells us no more than that the data do not rule out the possibility of gender parity for preschoolers, as hinted at by the WPPSI.

Gender differences in spatial ability

Lynn cites two studies that give 0.25 and 0.50 SDs (3.75 and 7.50 IQ points) as a female spatial deficit. In this case, I suspect that the higher estimate is closer to the truth thanks to data from Project Talent. Its sample was taken somewhat earlier, in 1960, but was of high quality: a 5% stratified sample of all American high schools, subjects aged 17 and numbering 88,000 (Flanagan et al., 1962, pp. 43-56). However, Project Talent is also relevant to assessing the significance of such a visual deficit. Its tests included both Visual Reasoning (visualizing the outcomes of manipulating figures in two and three dimensional space, plus seeing relationships in highly complex non-verbal patterns) and Mathematics (algebra, analytic geometry, calculus, also fractions and decimals). By the significance of the spatial deficit I mean its implications for achievement, particularly in mathematics, where it might seem most relevant.

Jensen (1980, p. 626) hypothesized that Visuospatial IQ is a potent mediator of mathematical ability and therefore, gender differences may account for the mathematical superiority of males. Later, he appears to have changed his mind. As Lynn notes, Jensen (1998) makes no mention of such a hypothesis in his discussion of gender differences and indeed argues for IQ parity. By then, he had read my analysis of the performance of Jewish Americans on Project Talent (Flynn, 1991, pp. 119-123), and perhaps it influenced him.

Project Talent (Backman, 1972, p. 5, Table 1) shows that when Jewish Americans are normed against non-Jewish white Americans (set at 100), they score 91 for Visuospatial IQ (a deficit of 0.6 SDs) and yet score 111 for Mathematics (an advantage of 0.73 SDs). It is of great interest that the difference between Jewish males and females for Visuospatial ability is almost exactly the same as that between non-Jewish white males and females: so the female deficit among whites in general is replicated within the Jewish subculture. These results are also supported by two smaller studies (Lesser, Fifer & Clark, 1965; Majoribanks, 1972). Not only do Jewish Americans do better on Project Talent Math, they outnumber non-Jewish white American mathematicians and statisticians by a per capita ratio of three to one (Weyl, 1969, Tables IV and V).

I conclude that women would suffer from their spatial deficit in some professions. Given equal incentive and opportunity, we would expect fewer female taxi drivers (they need excellent mapping abilities — at least needed them in the days before automatic guidance systems). But the example of Jewish Americans forbids Jensen's early hypothesis about mathematics. Local mathematicians and statisticians tell me they never manipulate figures in three-dimensional space in their thinking, although I should add that none of them are in Topology (the study of properties preserved through deformations, twisting, and stretching of objects),

The *g* data

When you give a subtest a *g* loading, you are measuring how well performance on it predicts performance on the whole battery of subtests taken collectively. When you rank the subtests into a hierarchy from highest *g* loading to lowest, you get what appears to be a hierarchy from the most cognitively complex subtest to the lowest. For example, digit span forward (just repeating digits from memory in the random order they are read out) has a lower *g* loading than digit span backward (where in addition you have to reverse the order). The latter is clearly a more complex mental operation. Assume that men and women were equal on all Wechsler subtests if you count all the subtests as equal. Now assume you weight the scores according to the *g* loadings (a test with 0.8 gets twice the weight as a subtest with 0.4). That might change the result in favor of men. The genders being equal in term of Wechsler Full Scale IQ might conceal the fact that men have an advantage the more complex the item. With this in mind it makes sense to see if there is a *g* difference between the genders as distinct from an IQ difference. I will call this a GQ difference.

In screening this data, I jettisoned Jensen (1998) on the WAIS as obsolete and took the larger female deficit from his analysis of the WISC-R. His results from other tests are not referenced but he says that the samples are large and representative and that is good enough for me. I have omitted small samples (under 400). I have omitted samples for black and Hispanic Americans in that this opens up a debate about their exposure to modernity. Four samples were for university entrants (Allik, Must & Lynn, 1999; Colom et al., 2000 – both his samples; Stumpf & Jackson, 1994). For the two samples from Aluja-Fabregat et al. (2000), I modified Lynn's reported results after consulting the original. The changes were slight and the fact that this was the only such case attests to his scrupulousness.

Up to now, my analysis suggests that women have parity with men for fluid *g* (the Raven's data) and are about 2.24 IQ points behind them for crystallized *g* (the WAIS data). The *g* data include many non-Wechsler tests. I surveyed their subtests and concluded that the crystallized versus fluid balance was much the same as for the Wechsler tests; and anticipated that the Wechsler female GQ deficit would hold for them as well. There was one exception: the ASVAB (Armed Services Vocational Aptitude Battery). As Jensen (1998, pp. 276-277) points put, its ten subtests include Auto and Shop Information, Mechanical Comprehension, and Electronic Information. These are far more "crystallized" than any Wechsler subtest and put women at an obvious disadvantage. Therefore, I grouped the data into ASVAB, Wechsler, and non-Wechsler.

Results

Table 5 shows a female deficit of 5.28 GQ points for the ASVAB, which hardly signals a female intelligence deficit. It also shows a deficit of 2.64 points for the

Wechsler tests, and female parity for the non-Wechsler tests. I cannot explain why the last does not match the Wechsler tests. I noted that much of the data is US data and explored the possibility that this discrepancy was peculiar to America. However, when I isolated the USA data, the result was a female deficit of 2.92 GQ points for Wechsler and parity for non-Wechsler, so that is not the explanation. The female GQs for the three kinds of tests would be 94.72, 97.36, and 100.09 respectively.

Table 5. *GQ difference between the genders.*

Nation	Ages	No.	Test	Gender Difference*	Reference
USA	6-16	Large-good	ASVAB	0.366	Jensen, 1998
USA	23	3797	ASVAB	0.45	Meisenberg, 2009
USA	16-17	913	ASVAB	0.24	Nyborg, 2015
Average for the ASVAB				**0.352** **5.28 GQ**	
USA	6-16	1868	WISC-R	0.189	Jensen, 1998
USA	16-89	2450	WAIS-III	0.20	Irwing, 2012
Netherlands	adult	519	WAIS-III	0.30	van der Sluis et al., 2006
Spain	16-94	1369	WAIS-III	0.16	Colom et al., 2002
Spain	16-34	588	WAIS-III	0.03	Dolan et al., 2006
Average for Wechsler tests				**0.176** **2.64 GQ**	
USA	18-23	Large-good	GATB	-0.527	Jensen, 1998
USA	14-17	Large-good	BAS	-0.002	Jensen, 1998
USA	17-18	102,516	SAT	0.24	Jackson & Rushton, 2006
USA	18-79	436	Various	0.14	Johnson & Bouchard, 2006
USA	16	2100	KABC	-0.15	Reynolds et al., 2008
USA	16-59	3884	W-J III	0.08	Keith et al., 2008
USA	16-59	3086	W-J III	-0.17	Keith et al., 2008
Portugal	13	1714	PF	0.13	Lemos et al., 2013
Portugal	16	1519	PF	0.29	Lemos et al., 2013
Scotland	11	70,000	CAT	-0.001	Deary et al., 2007
Spain	13	678	RTB	-0.21	Aluja-Fabregat et al., 2000
Spain	13	887	RTB	-0.17	Aluja-Fabregat et al., 2000
Median for non-Wechsler tests				**0.006** **-0.09 GQ**	

* Plus is a difference in favor of males, minus a difference in favor of females.

Analysis

Table 6 groups the data by age as much as possible, and looks for further subtleties in terms of kind of test. Insofar as there is data for specific ages or small age groups, there is no particular age that signals the beginning of a female decline. The SAT "drop" at ages 17-18 is offset by a "rise" on the GATB at ages

18-23. The SAT sample is biased against women in that it is self-selected toward those who aspire to university. The GATB (General Aptitude Test Battery – used by the US Employment Service) has subtests that include clerical aptitude, motor coordination, finger dexterity, and manual dexterity (Jensen, 1998, p. 285). Perhaps these favor women on balance. The values for schoolchildren and adults on the Wechsler tests are typical. However, there is female parity on the Woodcock-Johnson, which is a bit of a surprise in that its content is close to the Wechsler tests.

Table 6. *Female GQs by age (male = 100) for non-Wechsler and Wechsler tests.*

Nation	Ages	No.	Female GQ
Scotland	11	70,000	100.15 (non-W test)
Portugal & Spain	13	3,279	101.25 (non-W tests)
USA & Portugal	14-17	Large	99.31 (non-W tests)
USA	17-18	102,516	96.40 (SAT)
USA	18-23	Large	107.91 (GATB)
USA	6-16	1868	97.17 (WISC-R)
Spain	16-34	588	99.55 (WAIS-III)
USA & Netherlands & Spain	16-89/94	4338	96.70 (WAIS-III)
USA	16/18-59/89	11,726	99.75 (mainly W-J III)

The problem of external validity

At no age, not 15 or 16 or 17 or older, do modern women in developed nations begin an IQ decline vis-à-vis males. Women suffer from a spatial deficit that might dictate fewer of them in "mapping jobs". Modern women have a fluid intelligence of 100 (university Raven's data) to 100.5 (five modern nations Raven's data); and a crystallized intelligence of 97.26 (WAIS data plus non-Wechsler IQ) to 100 (non-Wechsler GQ). WAIS Verbal IQ is no higher than WAIS Full Scale IQ.

The interesting thing is this: no matter whether we take the lower values or a mean value, we would expect females to match males on mathematics and do no better than males at school and university.

Raven's IQ correlates with SAT-Mathematics at 0.76, as compared to SAT-Verbal at 0.49 (Frey & Detterman, 2004 – the breakdown into Math and Verbal courtesy of Meredith Frey). When Raven's is taken twice at an interval of a week to several weeks, it correlates with itself at only .82 (Raven). And yet, there is a dearth of women at the highest level of mathematics. Wechsler IQs (particularly Verbal IQs) are predictive of academic performance; indeed, universities use

SAT-Reading scores to isolate students at risk (Flynn, 2016, pp. 17-19). And yet, as we have seen, female high school graduates in America have a Grade Point Average (GPA) well above boys (boys get 70 percent of the Ds and Fs and girls get 60 percent of the As). About 80 percent of high school dropouts are boys. There is a similar pattern in the United Kingdom, Ireland, Scandinavia, Australia, New Zealand, and Canada. No advanced nation has been found to be an exception (Coates and Draves, 2006; Gurian, 2001).

Intellect and character

I suspect that there are genetic differences between men and women but that these have far more to do with character than intellect. It is politically incorrect to assert that women tend to be cleaner, more attentive to physical appearance, more skilled at arts that make home life attractive, and more likely to use charm rather than (overtly) aggressive behavior to attract the opposite sex. I will rely on those of both sexes who see through their eyes and not their ideologies.

First, women tend to be less violent and combative than men. Our nearest primate relatives suggest that over much of human evolution, males and females were subject to different selective pressures. Males competed for access to females by either violent combat or aggressive displays that intimidated rivals. Since aggressive males fathered the most offspring, their genes became dominant. Females perpetuated their genes to the extent that they raised their children to maturity, so that their children could reproduce. A bond with a male helpmate was advantageous. Therefore, genes for whatever helped domesticate males were positively selected. Much of human history is about the domestication of animals by humans, the domestication of people by living in larger communities (where they had to deflect violence outward), and the domestication of men by women. Violence has dropped over time as women achieved the equality that empowered them versus males in the home (Flynn, 2013, pp. 59-63).

Second, women are more sensitive to other human beings. Simpson et al. (2016): "Sex differences in social behavior are already evident in infancy. Female neonates, compared to males, make more eye contact, are more likely to orient to faces and voices, are rated as more cuddly, and exhibit stronger emotion contagion (e.g., contagious crying) and imitation." Greater eye contact persists from infancy into adulthood (Hittelman & Dickes, 1979; Leeb & Rejskind, 2004). I would like to know how many photo albums women and men compile respectively.

As Table 7 shows, at my university, the ratio of women (who complete degrees) falls from dominant to rare as we go from social science, to medicine and biology, to biochemistry, to chemistry, to applied math, to math and physics. Whether this is true elsewhere I do not know, but it is generally the case that women do better on applied math than on pure math.

Table 7. *University of Otago (2015): Ratio of female to male in various disciplines (completed degrees).*

Major completed	Female	Male	Ratio
Anthropology, Ecology, Psychology, Neuroscience, and Sociology	175	57	3.07-1
Medical School	144	103	1.40-1
Other medical (includes genetics)	87	48	1.81-1
Biology, Physiology and Zoology	80	62	1.29-1
Microbiology	24	18	1.33-1
Biochemistry	19	11	1.73-1
Chemistry	9	21	0.43-1
Applied math and Computers	13	42	0.31-1
Math and Physics	7	33	0.21-1
Economics	25	74	0.34-1

There are two ways of viewing this progression: that women value math more insofar as it has a human application, and less when it lacks any obvious human application, as when the pure mathematician finds the dance of numbers in itself elegant and inspiring. This would suggest that the female character trait of interest in people is responsible. On the other hand, math gets more difficult as you go from psychology to pure mathematics, which would accord with a gender difference in talent. Since either of these traits could be genetic in origin, I can see no easy way of evidencing one or the other. The case of biochemistry (women 1.73 to one) and chemistry (women 0.43 to one) might seem to signal being "people oriented" as a factor. However, it is easier to pick non-calculus options in Biochemistry than Chemistry. There is one anomaly: the ratio against women in economics is high at 0.34 to one. Evidently women do not feel that economics is about people. Given how it is taught, it is hard to disagree.

That fewer women attain the top in business, law firms, and so forth, has an easy explanation: they are less willing to ignore their human associations (spouses, children, friends) to work 80 hours a week like the fanatic upwardly mobile executive.

The reason for the superior female performance at school is abundantly clear: boys are more aggressive and combative and have a much harder time accepting school discipline whether it is rule- or self-imposed. They hand in assignments late (or not at all), miss school more often, drop out more often, and must be disciplined more often. In sum, two differences in character may explain women's under-performance in mathematics and over-performance at school.

Vive la difference

Let us assume what may not be true: that the current generation of women in advanced nations have been fully exposed to modernity and have a cognitive and emotive environment equal in quality to men; therefore, all of today's differences in character and intellect (as measured by mental tests) are largely genetically determined. Offered a trade-off between half of humanity who (statistically) are less murderous and aggressive, value human beings more, and make better students on the one hand, and (not quite) doubling the number of elite mathematicians on the other hand, my own preference is clear.

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Counting is not Measuring: Comment on Richard Lynn's Developmental Theory of Sex Differences in Intelligence

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Lynn's developmental theory of sex differences in intelligence provides one tentative explanation for the observed small male advantage in average IQ scores. Relying on indirect evidence, Lynn suggests that because a) brain size is positively associated with intelligence, and b) men have a larger brain size than women, c) men should have higher average IQ scores than women. However, straightforward evidence obtained using neuroimaging approaches shows that men's larger brains might be devoted to highly demanding visuospatial processing required by tasks on which they excel. Men's greater cortical values are not related to the general factor of intelligence (*g*). This advantage is translated into group abilities and specific skills.
Key Words: Brain size, brain structure, *g* factor, sex difference, measurement

1. Questioning the received wisdom

Scientists must follow the data, but selected data may or may not be appropriate for testing a theory. Furthermore, data might fail to show the required quality. Scientific theories could be correct regardless of the available data because the latter are useless on its current form.

I was intrigued by Lynn's developmental theory of sex differences in intelligence (Lynn, 1994). He questioned the received wisdom regarding this hot topic, both scientifically and socially. Lynn's theoretical framework and the datasets he presented in its support led to the conclusion that men do show a small average advantage of approximately 4 points on IQ scores.

For satisfying my scientific curiosity, I conducted several studies following Jensen's (1998) guidelines mainly based on the method of correlated vectors (MCV) (Aluja et al., 2002; Colom et al., 2000, 2002a). This research was based on the distinction between general intelligence (*g*) and intelligence in general (IQ) (Colom et al., 2002b).

As underscored by Jensen (1998), the scientific construct of general intelligence rests on the correlations among test scores rather than on their summation. Proper estimates of *g* requires computing the correlation between several diverse tests, each of which reflects general intelligence (*g*), group abilities (such as verbal or spatial ability), and specific skills tapped by each measure: "*an individual's test score (in either raw or standardized form) is not a measure of the quantity of the latent trait (e.g., g) per se possessed by that individual*" (Jensen, 1998, p. 311). Using straightforward words, ***counting*** is not measuring: the ***construct*** of interest (*g*) can be represented by different ***vehicles*** (psychometric tests, experimental tasks, or physiological indices) that provide different ***measurements***.

Following these guidelines I found that, consistent with Lynn's conclusion, there is an average sex difference regarding the measurements derived from the considered vehicles. However, the observed difference was not explained by the latent construct. Therefore, I concluded that group abilities and specific skills tapped by the vehicles must be responsible for the observed average sex differences in cognitive performance.

2. Research strategies

Nevertheless, reasonable reservations were raised regarding the MCV (Ashton & Lee, 2005). Therefore, I approached the key research problem using two further strategies: a) the nature of the vehicles (Colom & García-López, 2002) and b) latent variable modeling (Dolan et al., 2006, van der Sluis et al., 2006).

Regarding the first approach, we found that men outperform women in the Raven Progressive Matrices Test (a test with a clear visuospatial bias), women outperform men on the inductive reasoning test from the Primary Mental Abilities Battery (a test with a clear verbal bias), and there is no significant sex difference on the Culture-Fair Intelligence Test (the best available measure of fluid intelligence). Jensen (1980) agreed with Cattell (1980) in that the Raven test is "*less than ideal because of specific variance due to using only the matrix problem format. Cattell's Culture Fair test of g, which employs several different types of nonverbal reasoning items, does not contaminate the g factor with variance specific to item type*" (p. 363). We did show that vehicles are relevant for addressing this topic.

We have published several reports related to the Raven Matrices Test. Abad et al. (2004) applied Differential Item Functioning (DIF) to investigate sex DIF in Raven's Advanced Progressive Matrices (RAPM) in a sample of 1069 men and 901 women. Several biased items were detected, but a clear average male advantage of approximately 4 IQ points remained after controlling for the effect of these items. Colom and Abad (2007) reinforced this main conclusion after re-analyzing this dataset for replicating Mackintosh and Bennett's (2005) study showing that men outperform women in some Raven items, but not in others. We failed to replicate their findings, showing that average sex differences remain fairly constant across RAPM items. Therefore, the average male advantage on the Raven Matrices Test is robust. However, Colom et al. (2004) showed that the average male advantage on the RAPM (equivalent to 4.3 IQ points) turned out to be non-significant when average sex differences in spatial rotation were statistically controlled, which led to the conclusion that the former difference could be a by-product of the visuospatial format noted above.

The second approach was consistent with the main conclusion that the average sex difference in intellectual performance cannot be explained by the general factor (*g*). Analyzing the standardization samples of the WAIS-III for Spain (Dolan et al., 2006) and Germany (van der Sluis et al., 2006) using Multi-Group and Mean Structure Modeling we found that average sex differences were due mainly to group abilities rather than to the second order factor representing *g*. Men and women differ with respect to specific cognitive abilities, but not with respect to the general factor of intelligence (*g*).

3. The paradox (properly) resolved

In my view, the analysis of population differences can provide relevant clues regarding the psychological constructs of interest. This was behind my interest in the research summarized by the target article (Lynn, this issue). Actually, Lynn and I analyzed the standardization sample of the DAT-5 for Spain for testing his developmental theory of sex differences in intelligence (Colom & Lynn, 2004). The findings revealed that a) girls do better than boys at the younger ages; and b) their performance declines relative to boys among older age groups. The average sex difference for the DAT battery for 18-year-olds was equivalent to an advantage of 4.3 IQ points for boys. This difference is very close to the advantage that can be predicted from men's average larger brain size. These results for Spain were similar to those observed in the United States and Britain. After applying the MCV to this dataset we observed positive correlations suggesting that the difference can be explained by the latent construct. But my skepticism remained. I thought further evidence is required.

I admit that the paradox raised by Lynn is scientifically interesting: a) brain size is positively associated with intelligence, b) men have a larger brain size than women, and therefore, c) men should have a higher average IQ than women. However, Lynn has not analyzed the components related in the paradox using the same dataset. He relies on indirect evidence, and therefore the sequence cannot be properly tested until straightforward evidence is considered. For filling this gap, and for promoting further discussion, I will put on the table three studies published by my research group.

Using a VBM (Voxel-Based Morphometry) approach, Burgaleta et al. (2012) considered the components of the paradox underscored by Lynn, but analyzing the same dataset. These were their main findings: a) *g* was related to brain volume, b) men's brains were bigger than women's, but c) men did not outperform women regarding their *g* scores. Afterwards, we tested whether sex differences in brain volume were related to sex differences in specific cognitive skills for testing the suspicion noted above. Now average sex differences on mental rotation were related to sex differences in brain volumes. Therefore, we concluded that men's larger brains "*might provide extra cognitive resources to deal with mental rotation requirements*" (p. 66). A male advantage in average brain volume was observed here, but their extra volume was associated with greater scores on a highly demanding spatial test, not with *g*. This result was seen as consistent with Rushton and Ankney's (1996) hypothesis regarding the large amount of cognitive resources required by visuospatial processing. But it is also consistent with Lynn's speculation (this issue): "*the likely explanation of the evolution of greater spatial abilities of males is that during the last several millions years hominids became hunter-gatherers in which males specialized in hunting*". In short, men's greater brain volumes might be simply explained by their acknowledged advantage in visuospatial processing.

In the second study we applied a method for the automated segmentation of the hippocampus in 3D high-resolution structural brain MRI scans (Colom et al., 2013). We found significant relationships between hippocampal structural variations and general intelligence (*g*). However, the significant association was positive for men and negative for women. This key finding was interpreted according to the efficiency hypothesis: women show greater efficiency, meaning that they require less neural material for achieving behavioral results on a par with men.

Finally, applying a Surface-Based Morphometric (SBM) approach, Escorial et al. (2015) found that men show larger values in cortical thickness, cortical surface area, and cortical gray matter volume than women, even after controlling for body size. A key finding derived from this study was that the observed sex differences in the analyzed neocortical measures were unrelated to cognitive performance of men and women across four *latent* factors estimating processing speed, attention control, working memory capacity, and fluid intelligence. Men and women showed the same average performance level even when they differed on the considered cortical indices: "*quantitative differences between men and women were found in cortical thickness, cortical surface area, and cortical gray matter volume. These average differences were statistically significant even after controlling for body size. Men showed greater average values in the three cortical measures, but this did not evoke better cognitive performance*" (p. 361). Therefore, again women required less neural material for achieving the same cognitive ability than men. The former seem to be more efficient than the latter. We have observed exactly the same results studying a representative sample of children and adolescents from the Pediatric MRI Data Repository (Escorial et al., under review).

4. Conclusion

In conclusion, we must admit that the evidence summarized by Lynn (this issue) shows an average male advantage in general cognitive performance, as revealed by the Wechsler's scales or the Progressive Matrices Test. However, this average difference is limited to the considered *vehicles* of the *construct* of interest. Psychometric evidence for the latter is clearly still arguable. However, there is evidence that Lynn fails to address, showing that men's average greater values on brain structural measures are not automatically translated into better *g* values. Men's average advantage in brain structural features, such as cortical thickness, cortical surface area, and cortical gray matter volume, might be explained by their acknowledged average advantage in highly demanding visuospatial processing. Therefore, the paradox noted by Lynn (this issue) can be easily resolved: the greater brain size observed on average for men is devoted to cope with the large demands evoked by visuospatial processing, on which they clearly excel.

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Common Paradoxes in the Study of Sex Differences in Intelligence

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The study of sex differences in intelligence reveals a paradox. Data-oriented researchers consistently document reproducible differences, whereas leading textbooks, academics, and media consistently deny them. Perhaps, Lynn's extensive compilation of data on sex differences (this issue) will solve this paradox.
Key Words: Sex differences, Intelligence, ASVAB

Many textbooks and scientific papers find no, small, or inconsistent sex differences in intelligence, whether defined as IQ or *g* (e.g. Jensen, 1998). Richard Lynn therefore deserves credit for explaining why it has been so difficult to see the differences and for amassing evidence that they are reproducible. Lynn first points out that several specialists in the area of psychometrics, such as Matarazzo, Kaufman and Lichtenberger, Voyer, Voyer, and Bryden, Hedges and Newell (all cited by Lynn in this issue), called attention to the fact that early intelligence test developers – such as Binet, Terman, and Wechsler – deliberately removed sex differences that inevitably popped up in their standardization studies; that they carefully counterbalanced or eliminated items or subtests showing sizeable sex differences, that they systematically eradicated "gender biases" and that they took out measures clearly favoring males (e.g. Spatial Perception, Mental Rotation). They also excluded tests of verbal fluency and location memory where typically women score higher. The implicit understanding seems to have been that tests documenting a sex difference in intelligence would neither satisfy equality-oriented colleagues and publishers, nor be acceptable in academia or in other professional or public gender sensitive circles, and that they perhaps would not sell well.

To be sure, there are other ways to not see the sex difference. One is to only sample pre-pubertal children, where sex differences are known to be small or absent. Collapsing pre- and post-pubertal scores will, wittingly or unwittingly, reduce overall statistical significance. Moralizing and the Equality and Blank Slate illusions (Gottfredson, 1994, 2000; Nyborg, 2003; Pinker, 2002, 2006) have also long barred the search for sex differences in intelligence. Even if a good deal is published about sex differences in technical journals of education for example, they are often reported as an aside in studies dealing mainly with something else, as many researchers find them too small to be interesting.

This is all the more surprising because sex differences could, if substantiated, provide an objective explanation of the long history of male dominance in areas requiring raw intellectual power (e.g. Murray, 2003). It could explain, at least in part, why males throughout history have tended to dominate in politics, warfare, chess, musical composition, mathematics, science, business, and other areas requiring intellectual brilliance. It could facilitate our understanding of why so few women get Nobel Prices and mathematical Fields Medals (Nobel, 2016). Seen in this light, it is paradoxical that many experts still support the idea of zero adult sex differences in intelligence, and tend to rather support any other explanation, such as learned helplessness, glass ceilings, and old boys networks.

Perhaps Blank Slate ideology and the equality illusion have also promoted another inconsistency called The Rushton/Ankney paradox (Ankney, 1992; Rushton, 1997). Briefly, 1) the male brain is on average 100 cm^3 larger than the female, 2) IQ correlates from .24 (Pietschnig et al., 2015) to .44 (Rushton & Ankney, 1996) with brain size, but 3) the sexes do not differ in intelligence. The usual explanation for the paradox is that males need the extra brain power for controlling muscles for killing and raping, but the brain size-IQ correlation survives control for overall body size. Obviously, these paradoxes disappear the minute it is documented scientifically that males have a reproducible intellectual lead. This is precisely what Lynn's massive compilation of data does. The research reported below provides further details.

A cross-racial example of evidence for sex differences in general intelligence and achievement

Figure 1 illustrates age differences in the ASVAB subtest scores and the *g*-factor scores, expressed in *d* units, from age 12 to 17 in the NLSY97. The curves are based on cross-racial data for 6,912 adolescents 12 to 17 years old living in the US in 1997 (3,783 whites, 1,345 Hispanics, and 1,784 blacks, respectively). The total sample represents 15+ million young Americans. Race-separate analyses suggest that IQ drops after age 16 in the Hispanic and black female samples, but not for the white female sample. The decline may be real or due to some unknown sampling error.

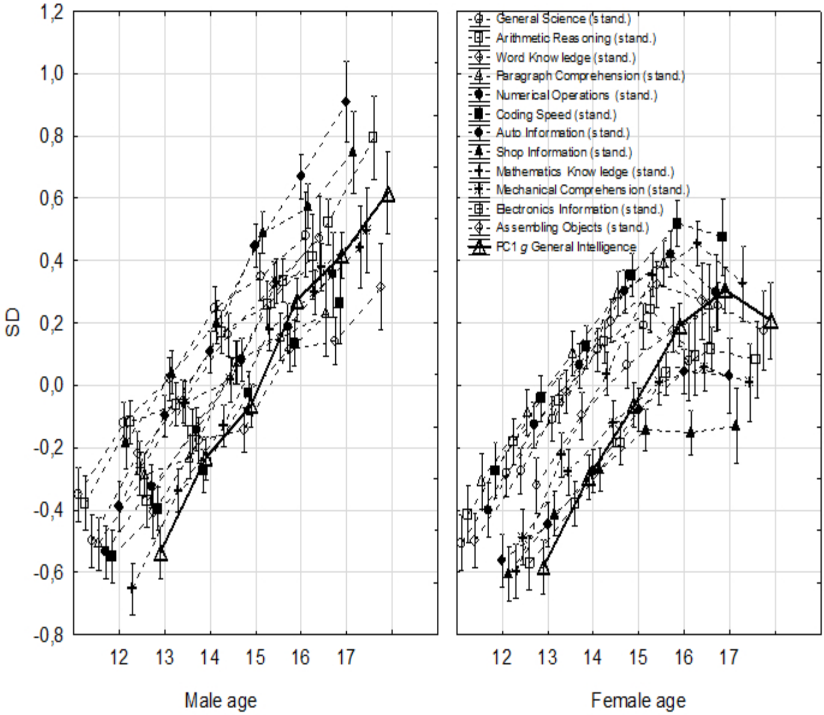

Figure 1. *Total sample male and female standardized age differences in general intelligence g (unrotated first principal component, fully drawn line), and in the 7 CAT-ASVAB (1997) subtests (dotted lines) with g-loadings above 0.80, from which the g factor was derived. Vertical bars denote 0.95 confidence intervals. Female IQ no longer rises after age 16 whereas male IQ seems to develop further. From Nyborg, 2015; with permission.*

Figure 2 depicts age differences in the subsample of white 12-17 year olds. It demonstrates that white pre-pubertal boys hold a slight lead in intelligence development, which first becomes statistically significant around age 15. Lynn readily admits that this speaks against the first version of his developmental theory (1994), as it hypothesized that the earlier bodily and brain development of pre-pubertal girls, relative to boys, also conferred on them a pre-pubertal intellectual lead. Thus, although boys' pubertal bodily and brain development lag about 1-2 years behind girls', they enjoy a slight intellectual advantage. The fact that girls in general get higher grades in school is thus not related to IQ. It should be noted that the ASVAB contains tests of mechanical comprehension and electronics info, but not for example a verbal fluency test, which means that a male advantage should be expected. It is unfortunate that there are no NLSY97 data before age 12, so this is not a fully pre-pubertal age group.

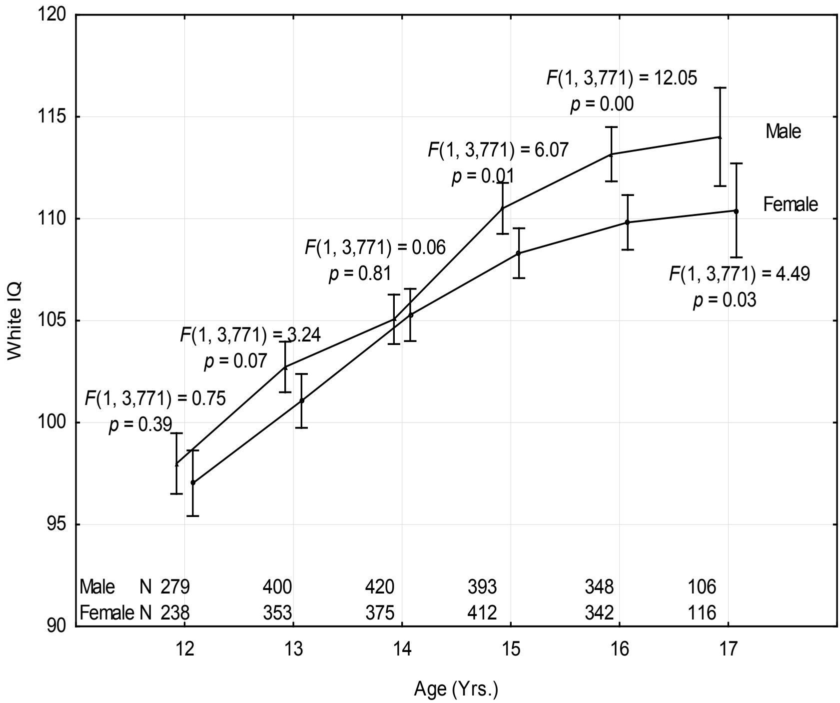

Figure 2. *White average sex differences in IQ across age, N, and results of Univariate Planned Comparisons (NLSY97 data). Vertical bars denote 0.95 confidence intervals. The sex-age difference pattern suggests that white male IQ development stabilizes later and at a higher level than female. From Nyborg, 2015; with permission.*

There is general agreement in the literature that the male IQ distribution is wider than the female. Figure 3 confirms this by plotting the male and female IQ distributions for 17-year-old whites from the NLSY97 data. Presuming that CEOs of big business stock exchange quoted companies are recruited based on an IQ of 145, Figure 3 suggests that there should be about 20% qualified females in this profession. This proportion is in fact very close to reality (Corporate Governance, 2013), at least in Denmark.

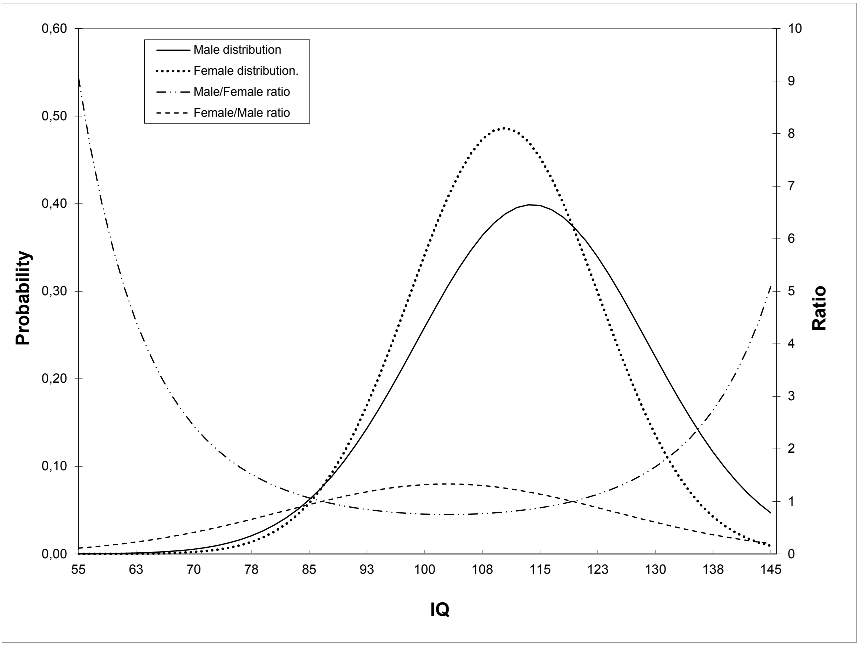

Figure 3. *White 17 year old subsample sex distributions, probabilities, and ratios as a function of their unweighted age means and SDs (NLSY97 data). For major achievements requiring IQ 145, there will be 5 males for each female, and the probability of living with a devastatingly low IQ of 55 is many times higher for males.*

The data presented above confirms that there are reproducible sex differences in IQ means and dispersion, and that these differences do translate into expectable sex differences in real-life achievement. They also solve, at least in part, the common paradoxes in sex differences research.

The future

It remains to be seen whether the empirical evidence amassed by Lynn in this issue will now suffice to convince a sceptic majority about the real existence of an adult mean sex difference in general intelligence of about 4-5 IQ points favoring males. The next step is to acknowledge that this moderate average sex difference combines with the larger male dispersion of IQ scores, and adds up to a male/female ratio of about 80/20 at IQ 145, from which group the highest educational and occupational echelons largely recruit their members, despite years of affirmative action (Nyborg, 2015).

At least, after Lynn's systematic compilation of the relevant data, it is no longer scientifically acceptable to continue to tell readers of general textbooks and specialized publications that there is NULL sex difference in general intelligence. To the contrary, there is a small but reproducible adult sex difference, and it has been demonstrated to have practical value. Moreover, the widespread equality dogma is an illusion no longer supportable, at least not with respect to sex differences in intelligence and related achievement.

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Cognitive Sex Differences: Evolution and History

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We add results from studies in Germany and Brazil supporting Lynn's theory on cognitive sex differences and their development. We show that there are associations between hormonal transitions during adolescence, especially in women, and increasing sex differences in cognitive abilities, particularly spatial ability, during adolescence. We suggest that such maturation-related changes make sense from an evolutionary perspective, as cognitive and ecological specializations of the sexes, with the benefit of increasing group fitness due to differentiation of social gender roles. However, historical and cultural change has reduced male-favoring gender differences in education and in many cases reversed them. Together with changes in the job market this has modified formerly stable sex differences.

Key Words: Sex differences, Intelligence, Brain development, Hormonal transitions, Adolescence, Gender roles; STEM

In science, there exist long-standing questions on which no consensus has ever been reached, whether as a result of limitations in available data and methods, reluctance to accept scientific results for political and zeitgeist reasons, or a combination of both. One of these subjects are sex differences in behavior and abilities, especially cognitive ability. In his target article, Richard Lynn raises the question whether there are differences in intelligence between men and women, a subject he has pursued for much of his life (Nyborg, 2013). Lynn gives an overview on this issue and presents a huge collection of data from studies done around the world to demonstrate that such differences exist and how they can be explained by evolutionary theories.

According to Lynn's *developmental theory*, sex differences in intelligence are a result of differences in development based on different selective challenges for men and women in the evolutionary past. General intelligence measured with IQ tests is about the same in boys and girls until age 15 or 16, but then differences begin in favor of males. Divergences are even more obvious in domains: The male advantage is mostly in spatial ability and also in math and science abilities. Lynn's evolutionary explanations are based on the assumption that the most important task of male ancestors was hunting, often coordinated in groups, which favored selection for greater skills in spatial thinking. Also for warfare, spatial ability was important, e.g. finding paths, throwing spears and stones, using arrows and bows. Females were tasked with child rearing and with gathering vegetable foods meaning a higher selective pressure on verbal ability and social as well as emotional competences. This may go along with personality differences, e.g. for men supporting aggressivity and self-assertion in social hierarchies, for women empathy and kindness – boosted by the typical sex stereotypes. We will look now in two very different samples whether Lynn's first thesis (higher intelligence for males) and second thesis (higher intelligence from age 15/16 years onward) can be supported or has to be rejected by empirical data.

Research: Study at the German gymnasium

Also our own research with an above average sample in Germany supports Lynn's thesis. We rely on pupils at the German gymnasium, the academic-track school type that is attended by 25 to 50% of the age cohort. The sample consists of *N*=522 pupils in the state of Baden-Württemberg. Of these, 47% were at the regular gymnasium, and 53% in a gifted track. Their ages ranged from 10 to 19 years, and grade levels from 5 to 12. The pupils were tested with the German version of the Cognitive Abilities Test (CogAT, in German named "KFT") with verbal, math (quantitative) and figural (nonverbal) scales. The short form of the CogAT was used, which does not contain mental rotation tasks (as a result rather *under*estimating cognitive sex differences favoring males). Study details were described by Heller (2002) and Rindermann and Heller (2005); the results on sex differences were not published before.

For the combined sample of 522 pupils, the average age-standardized intelligence level for boys was 122.12 (*N*=259, *SD*=14.21) and for girls 117.23 IQ points (*N*=263, *SD*=13.78). This supports the general sex difference assumption of Lynn, but it says nothing on his developmental theory because this first analysis combined ages 11 to 18.

However, regarding the IQ difference it is frequently mentioned that girls are faced with more obstacles than boys finding access to a high-ability track in school. If this were true, they would be more strongly selected for their ability level. In this case the gap in the general population would be *under*estimated by our result of about 4.89 IQ points! But, this is no average sample and according to the high-end-male thesis (Nyborg, 2003) there are more gifted boys and men than girls and women – explained by the larger male standard deviation in abilities leading to a higher fraction of the gifted but also of the mentally handicapped among boys.

Richard Lynn not only assumes a difference in intelligence but also a difference in the development of intelligence. What do our data show? In Table 1 the groups are analyzed separately by grade level.

Table 1. *Sex differences (in IQ points) in German CogAT in gymnasium (regular vs. gifted track).*

Grade	Modal age (years)	Sex difference		
		Regular gymnasium	Gifted track	Together
5	11	1.13	4.78	2.95
6	12	1.81	7.34	4.57
7	13	1.77	1.60	1.69
8	14	5.78	2.58	4.18
9	15	3.25	2.71	2.98
10	16	2.95	3.66	3.31
11	17	4.17	4.56	4.36
12	18	3.07	4.57	3.82
Mean sex difference		2.99	3.97	3.48
Correlation		.516	-.149	.147

Notes: Positive sex differences mean higher IQ for boys. Modal age is the typical age of pupils in a grade. Regular gymnasium (*N*=248, mean age-scaled IQ 115.56, *SD*=13.04), gifted track gymnasium (*N*=274, mean age-scaled IQ 123.36, *SD*=14.20), surveyed 1991 to 2001 in Baden-Württemberg. Correlation is between grade and sex difference (boys' IQ minus girls' IQ). Positive correlation means that the difference favoring boys increases with grade-age. The total average of a 3.48 IQ points difference is not identical to the one mentioned in the text (4.89 IQ) because for Table 1 grade level averages were used, in the text individual averages across grades.

Among students in the gifted track there is no increase of the male-female gap with age. The correlation between grade-age and the gap is even negative, with $r = -.15$. But in the more average normal gymnasium sample the correlation is highly positive with $r = .52$. Summarizing, among the more highly selected gifted and their typical male advantage (high-end-male thesis) there was no increase, but in an average to above average sample the male-female gap became larger with age supporting the developmental theory. Generally, the gap may be even underrated because no mental rotation test was included and because girls could be more strongly selected for ability to attend a high ability track.

The pattern is far from being outlandish as another German study (Saß, Kampa & Köller, 2017) reports a similar IQ difference increase during adolescence: The older students become (here similarly from grade 5 to 13), the higher become correlations between sex and *g*, from $r = -.08$ favoring girls in grade 5 to $r = +.40$ favoring boys in grade 13. Intelligence was also measured with the German CogAT, however only with verbal and figural scales, not with numeric ones, leading to an underestimation of boys' intelligence. The authors explain the male IQ advantage with a higher selectivity among boys – fewer boys of an age cohort (45% vs. 55%) attend the gymnasium leading to a higher ability level for them compared to girls. However, in our own sample were 53% boys meaning a higher selectivity of girls, but still the intelligence level of boys was higher.

Further research: Study in Brazil

A second study, done in Brazil with quite average samples by Carmen Flores-Mendoza and colleagues (Flores-Mendoza et al., 2013), also supports Lynn's first claim, that there is an IQ difference favoring men: On a *g* factor extracted from a composite test the average difference was 3.8 IQ points, excluding mechanical reasoning the difference was 2.7 IQ points. Looking at development and using the Standard Progressive Matrices (SPM) test, the IQ gap in children was −1.2 IQ points favoring girls but for adults it was +1.5 IQ points favoring men (Flores-Mendoza et al., 2013, Table 4). Again, also Lynn's second thesis was supported.

Two independently conducted and analyzed studies in two different countries using different ability tests and different sampling procedures and with selected or non-selected groups at different ability levels confirmed Lynn's theory on cognitive sex differences and their development.

Historical changes

However, things may change with time. The best example is the “FLynn effect”, the 20th century increase of average IQ in developed countries, now followed by increases in regions at relatively low ability levels such as Africa (Flynn, 2012; Lynn, 2013; Meisenberg & Woodley, 2013; Pietschnig & Voracek, 2015; Rindermann, 2013; Rindermann, Schott & Baumeister, 2013).

In the last two centuries women became successfully integrated in the educational system and in modern countries their average educational level today is higher than that of men. Additionally, there are programs supporting women to pursue careers at universities and in STEM (Science, Technology, Engineering and Mathematics) fields that demand high cognitive ability as well as high ambition (Ceci, Williams & Barnett, 2009) – even in Arab countries (e.g. Rindermann, Baumeister & Gröper, 2014).

Insofar as education, invested time and motivation and also role models are important for cognitive development, ability levels and patterns can change, including the male-female-gap. Some support can be found in ethnic differences within Western countries, which became smaller with time (Rindermann & Thompson, 2013; te Nijenhuis et al., 2004). Similarly, there is some evidence for shrinking male-female gaps, at least in the top ability realm: According to Wai et al. (2010), in the United States, mathematical reasoning differences in student achievement tests became smaller in the last generations. So evolutionary factors leading to stable differences between groups are important – but they are not the whole story.

Adolescence, hormones, and sexual dimorphism in the brain

Let’s have a closer look at evolutionary mechanisms. The developmental theory and evolutionary explanations hint that sex differences are caused by hormonal changes during the life course, and that they probably evolved with sex differences in social behavior. Therefore we want to have a closer look at studies on sexual dimorphisms in humans and the possible role of circulating hormones and periods of hormonal transitions. This includes in particular the potential adaptive value of sex differences in spatial ability.

Sexual dimorphism is part of *Homo sapiens* and its evolution. It is detectable in many physiological traits, in morphology and disease susceptibilities, in both modern and archaeological populations (e.g. Bejdová et al., 2013; García-Martínez et al., 2016; Morrow, 2015; Schlager & Rüdell, 2015). It would be unlikely that sex has no influence on psychological characteristics, especially as effects on brain development are also observed: Wang et al. (2012) estimated an average male-female difference of brain volume via MRI of about 11%.

Differences were found in gray matter, white matter and cerebrospinal fluid. Environment is able to explain only a small part of this variance. Neuroimaging techniques also proved sexual dimorphism in brain structure, baseline neural activity, neurochemistry, and task-related neural activation (Sacher et al., 2013). Genes have been found on the sex chromosomes which influence the early development of the male central nervous system (Johansson et al., 2016).

Although first gender differences in behavior are apparent in early childhood, their expression mostly takes place during puberty due to changes in circulating hormones (Wells, 2007). Puberty is characterized by rapid growth and sexual development, e.g. in levels of gonadal and growth hormones, caused by major functional alterations in the hypothalamus and pituitary. Changes in physical traits and hormone levels are accompanied by changes in behavior and emotions and by changes in social roles, from the protected child to a sexually active adult (Lerner & Steinberg, 2004). Lynn's observation of increasing sex differences from age 15 onward indicates that differences in cognitive development between males and females could be connected to such changes in circulating hormones. But is there any evidence?

Females go through four major hormonal transition periods, each with characteristic estrogen levels and prevalence of depression (Barth, Villringer & Sacher, 2015). Levels of sex hormones rise in puberty, stay high during pregnancy, and fall postpartum. They start to decline during the perimenopause and remain permanently low after menopause. There are complex interactions between hormonal levels and brain development. For adults, brain areas with high levels of estrogen and androgen hormone receptors show stronger sexual dimorphism in size in comparison to those with lower levels (Goldstein et al., 2001).

Does estrogen contribute to the sexual dimorphism in intelligence? In a meta-analysis of Hogervorst and Bandelow (2010) some support has been found for the hypothesis that the decrease of the estrogen level after menopause negatively affects cognitive development but findings were not generally supported by all included studies. Wolf (2003) showed that the replacement of estradiol, an important estrogen, improves general cognition and especially verbal cognition. For males, a relation between the activity of sex steroids in the normal range and changes in sex differences in spatial ability could not be detected (Liben et al., 2002). However, strongly reduced secretion of steroids due to adrenalectomy (surgical removal of adrenal glands) causes lower performance in spatial memory (Luine, 1994), whereas testosterone replacement therapy in older men increases cognitive performance (Wolf, 2003).

After adolescence, females show larger cortical volumes in areas of the precentral gyrus, orbitofrontal cortex, superior frontal and lingual gyri; males show larger frontomedial cortex, hypothalamus, amygdala and angular gyrus (Goldstein et al., 2001). Negative correlations between regional gray matter and spatial intelligence were found by Colom et al. (2009) for two of the brain areas which are larger in females, the precentral and the lingual gyri, but positive ones for the superior frontal gyri.

Evolution and adaptation to gender roles

Spatial thinking abilities were very important in a pre-GPS time, when unknown environments could be harmful and being lost was often synonymous with being dead. Cashdan and Gaulin (2016) discussed the evolutionary meaning of sex differences in spatial cognition by arguing that higher spatial abilities generate advantages for men in mating competition by increasing the numbers of potential mates and in hunting by allowing hunters to pursue their prey into unknown territories (and back). At the same time, lower spatial abilities may cause a tendency for women to avoid venturing far from home, thereby reducing risks and increasing parental investment by favoring close bonds between mothers and children. Accordingly, lower spatial ability of women would generate a selective advantage by increasing the survival of offspring due to a stronger focus on home and children. Human groups exhibiting this pattern of abilities will have been more successful than groups composed of sexes with similar abilities.

Conclusion

The coincidence of hormonal and cognitive development with selective challenges and age-related tasks of the sexes seems not to be accidental. The impact of sex hormones on cognitive abilities, especially related to spatial ability, does make sense from an evolutionary perspective. Lynn's developmental theory of cognitive sex differences is backed by this theoretical outlook. Both sexes are adapted to their different tasks in Palaeolithic hunter-gatherer groups, and the cognitive differences develop exactly at a stage of life in which they become necessary for successful reproduction. This was crucial for the fitness of individuals as well as of human groups and populations. Women, tied more closely to their home camps by poorly mobile children, needed social rather than spatial competences, whereas men, ranging over a wide area for hunting and sometimes raiding, needed an opposite pattern. Higher male spatial ability can average out with higher female verbal ability leading to similar general ability levels on conventional IQ tests.

However, there is a possibility for the evolution of higher “general” intelligence of males because for men a single mistake in hunting or warfare could cause death, and a steeper relationship between social dominance and reproductive success imposed stronger selection on the ability to attain high status. This is especially true for polygynous societies which had been in the past the majority. On the other hand, the need of women to protect themselves and their children from dangerous males and to adapt to a new social environment have led more in direction of social, emotional and verbal abilities.

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The Male Brain, Testosterone and Sex Differences in Professional Achievement

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Lynn argues that sex differences in intelligence and drive (underpinned by testosterone) help to explain sex differences in high achievement. This comment proposes that this view can be developed by looking at Baron-Cohen's concept of the 'male brain', which in its extreme manifestations presents as autism-spectrum disorders. It shows that this personality type — specifically a moderately strongly male brain combined with the outlier high IQ also more common among men — is associated with genius, and so the highest levels of achievement, and is partly a reflection of elevated testosterone. Thus an optimally high level of testosterone, also associated with faster life history strategy, is behind both elevated male drive and a greater ability to innovate, systematize and make important breakthroughs, leading to the highest levels of professional achievement. The comment shows that the 'male brain' is independent of intelligence and that even the highest echelons of the 'oldest profession' are male dominated, as the male brain model would predict.

Key words: Male brain; Autism, Asperger's; Genius, Life history theory

One of Lynn's pieces of evidence for his developmental theory of sex differences in intelligence is that males dominate the highest levels of intellectually demanding professions, such as medicine. Ability in these professions would be strongly predicted by high intelligence. He puts this down to three factors: (1) Adult males have slightly higher average IQ than adult females; (2) Adult male intelligence has a slightly wider standard deviation, meaning that a higher percentage of males are outliers, with extremely high or low intelligence; and (3) Males are more competitive than females, meaning that they have a stronger drive to reach the top of their profession. Accordingly, Lynn argues, the 'glass ceiling', which supposedly explains male dominance at the highest levels of achievement, is a myth. The situation can be more simply explained by intelligence differences and competitive drive, something associated with testosterone levels, which are higher in males.

Baron-Cohen's Male Brain Theory

Intelligence and competitiveness may explain most – though not all – of these differences in accomplishment. A complementary theory is Baron-Cohen's (2002) theory of the 'male brain', which he contrasts with the 'female brain'. It shows that a variety of other characteristics contribute to explaining the over-representation of males in the highest echelons of the professions, beyond simply 'drive' and 'intelligence'.

Baron-Cohen reviews a large body of evidence which demonstrates that males and females, even in early childhood, approach the world, on average, in a fundamentally different way. The 'male brain' is focused on systemizing. According to Goldenfeld et al. (2007), "Systemizing is the drive to understand the rules governing the behaviour of a system and the drive to construct systems that are lawful. Systemizing allows one to predict and control such systems." This, it appears, would make males inclined or adept at the hypothetico-deductive method, generally considered the essence of science. The 'female brain' is less focused on this and instead is more focused on 'empathizing', defined by Goldenfeld et al. (2007) as follows: "Empathizing is the drive to identify another person's thoughts or emotions, and to respond to their mental states with an appropriate emotion. Empathizing allows one to predict another person's behaviour at a level that is accurate enough to facilitate social interaction."

Baron-Cohen reviews evidence that females are better at or more interested in empathizing. Girls are better at turn-taking, less interested in rough games (as they may hurt people), are more likely to comfort strangers and share the distress of their friends, have better theory of mind, value harmonious relationships over power-centered ones, and are less aggressive. Boys prefer building-related toys, occupations focused on mechanical or theory-based systems (e.g., engineering, computer programming), and math-based subjects (e.g., theoretical physics). They have better construction abilities, superior spatial intelligence, a finer eye for detail, superior map reading skills, superior motor skills (making them better at hitting a target), greater ability and interest in organizing and classifying, and are less prone to allowing extraneous information to interfere with these processes. Baron-Cohen argues that the most extreme 'male brain' would be autistic and very low in empathy but very high in systemizing. The extreme female brain, by contrast, would be very empathetic but would be 'system blind'.

The Extreme Male Brain and Genius

If we return to Lynn's discussion of male dominance of the highest levels of achievement, we can see that the 'male brain' (though perhaps not in its most extreme manifestations) is very likely to play a significant part in it. Many analyses of those who are considered scientific geniuses — those who are widely acknowledged to have made an enormous and ground-breaking scientific contribution — have found that they fall into a clear type. They are overwhelmingly men and their achievements provide at least indirect evidence for an extremely high IQ, just as Lynn's model would predict. However, they combine this with evidence of moderately low Agreeableness and moderately low Conscientiousness (e.g. Eysenck, 1995; Feist, 1998, 2007; Post, 1994; Rushton, 1990, 1995; Simonton, 1988, 2009). In other words, they are moderately low in empathy although it has been found that academic achievement is weakly positively correlated with Agreeableness and Conscientiousness (e.g. Almlund et al., 2011; Conard, 2006). New ideas will in many cases offend established interests, but because the prototypical genius is moderately low in empathy he either doesn't care about offending people or doesn't understand that he is doing so. People's feelings are irrelevant to what he wants to achieve, and he is highly able to focus on his work and ignore what he would see as the distraction of other people's feelings about his findings (see Dutton & Charlton, 2015). In addition to empathy, conscientiousness tends to be lower in males than in females (Weisberg et al., 2011). Moderately low conscientiousness, which can be expressed as non-conformity, predisposes people to think 'outside the box' and to break the established rules.

Simonton (1988, 2009) has shown that highly original scholars tend to begin their academic lives in a more systematic discipline in which the degree of 'male brain' and autism traits are higher and that scientific geniuses tend to be obsessional, anti-social, socially inept, relatively friendless and extremely narrow in their interests. But they have a fantastic eye for detail and are focused on rules and facts. In other words, they show many of the signs of high-functioning autism and of a relatively extreme male brain. Feist (2007) has also shown that autism traits are prevalent in the best scientists.

We have seen that Lynn's model partly involves testosterone, leading to increased male drive. Baron-Cohen's model adds an important nuance to this, because he has shown that testosterone is also associated with the 'male brain'. Baron-Cohen (2002) has assembled evidence that autistic males have high testosterone levels expressed in precocious puberty and a low 2D:4D digit ratio (Manning et al., 2001). So the elevated male competitiveness that Lynn highlights could be subsumed under Baron-Cohen's model. Men dominate high status positions partly because a higher percentage of them combine very high IQ with moderate levels of autism which is partly a function of high testosterone. Indeed, more recent research has shown that autistics have been exposed to elevated fetal steroidogenic activity, including elevated levels of testosterone, as evidenced by tests of their amniotic fluid (Baron-Cohen et al., 2015). In addition, Dawson et al. (2007) have shown that autism is associated with a distinct intelligence profile. Autistics score strongly on Raven's Progressive Matrices relative to scores on broader IQ tests, on average 30 percentile points (about 12 IQ points) higher, and in some cases 70 percentile points (about 30 IQ points) higher, than they score on Wechsler subtests. The Raven test is a test of inductive reasoning that requires the recognition and application of rules. Strong performance on this test is consistent with the view that autistics are very strong systemizers. It is also consistent with evidence that females have poorer spatial intelligence than do males (Neisser et al., 1996). Interestingly, adult women who were exposed to particularly high levels of androgens in utero due to having congenital adrenal hyperplasia score significantly higher on spatial ability tests than do controls (Resnick et al., 1986) while there is evidence that testosterone level in healthy males is positively associated with spatial ability (Janowsky et al., 1994).

Genius and Life History Strategy

In terms of evolutionary psychology, we can distinguish between fast and slow life history (LH) strategists. Fast LH strategists are adapted to unstable environments. They live life quickly and invest more of their resources in mating effort. As the environment becomes more stable, the maximum carrying capacity for a species is reached and there is greater competition within the species. When the ecology is predictable yet harsh, one is more likely to win this competition via a slow LH strategy in which one learns a great deal about the environment and invests energy in nurturing one's offspring so they can do likewise. One also becomes increasingly specialized for a specific niche. In such an ecology, cooperative groups are more likely to survive, so impulse control and agreeableness are part of a slower LH. In general, a slow LH (Rushton, 1995) favors higher socioeconomic status whereas a moderately fast LH combined with extremely high intelligence predicts the highest levels of achievement. Certainly, analyses of scientific geniuses seem to imply that they combine outlier high intelligence with moderately high psychoticism, the latter being a dimension of a fast LH (see Dutton & Charlton, 2015). Males are faster LH strategists than females, and they have a broader intelligence range. Accordingly, they are much more likely to attain the highest positions. This is consistent with evidence that when controlling for national IQ, national average testosterone level (as evaluated by a variety of markers) predicts per capita Nobel Prize attainment and important scientific publications (Van der Linden et al., under review).

The Male Brain, Genius, and Intelligence

It might be argued that the 'male brain' is essentially a proxy for intelligence and can thus be subsumed into Lynn's intelligence model, but the evidence is not in favor of this. Baron-Cohen has reduced his model down to tests of EQ (Empathy Quotient) and SQ (Systemizing Quotient). He has also constructed a specific test to gauge Autism Quotient (AQ). A number of studies have found that there is no statistically significant correlation between SQ and intelligence (e.g. Ling et al., 2009; Yajnik, 2014). Accordingly, Baron-Cohen seems to be correct in proposing that the 'male brain' model is independent of general intelligence.

However, interestingly, SQ and EQ are not polar opposites. Groen et al. (2015) have found a significant correlation between SQ and EQ of only -.10 in a healthy sample. Wheelwright et al. (2006) found the following significant correlations: AQ and EQ (r = -.50), AQ and SQ (r = .32) and SQ and EQ (r = -.09). This would seem to imply that only a tiny element of systemizing ability involves the inability to empathize. Indeed, it may be the case that the heights of achievement are predicted not by an extreme male brain but rather by an optimum 'moderately strongly male brain' combined with high intelligence. This would be consistent with the evidence that scientific geniuses combine very high intelligence with moderately high psychoticism. One aspect of achievement is the ability to promote one's findings, get funding for research, collaborate to some extent and engage in other practical pursuits which require at least some "people skills" and therefore empathy, or at least cognitive perspective taking: the ability to understand other people's point of view (see Dutton & Charlton, 2015). Indeed, perhaps there is a degree to which being able to systemize makes you better at empathizing, possibly because you can better categorize different people and calculate how these different types will differentially respond to the same stimuli. One of the statements on the SQ-R is in fact, 'I find myself categorizing people into different types (in my own mind)' (Wheelwright et al., 2006, Appendix A). The advantage of so-doing would be that one could make predictions about the potential behavior of these 'types' and moderate one's own behavior accordingly. In much the same way, Kaufman et al. (2011) found that IQ had a modest but significant 0.3 correlation with ability to solve social problems, meaning that general problem-solving ability can effectively be deployed as a means of scoring moderately well in empathy.

Prostitution

So, we can conclude that Lynn is right in asserting that there exists no ‘glass ceiling’ for women and the ‘male brain’ model adds nuance to his argument regarding the importance of testosterone in explaining sex differences at the highest levels of achievement. In this regard, Lynn jokes that the only profession which males do not dominate at the highest levels is the ‘oldest profession’; that is to say, prostitution. But, let’s actually look at this possibility.

A prostitute is generally defined as ‘a woman who engages in sexual activity for payment’. To the extent that women sexually select for status which they do to a greater extent than men (Buss, 1989), it can be argued that prostitution is simply the most extreme and overt form of the sexual selection strategy engaged in by females: sex in return for investment (money or payment in kind). But there are different kinds of prostitution. Probably the highest status form is hard core pornography, whereby the female is filmed having sex with a sexually attractive male for the masturbatory pleasure of male viewers. ‘Escorts’ may be compelled to have sex with unattractive males, but this is not the case in hard core porn. But even this ‘profession’ is male-dominated, in the sense that the creative forces behind it, those who make the real money out of it – the directors of the films – are overwhelmingly male, to the extent that it is noteworthy when there is a female director. Anna Span, who subsequently ran for the UK parliament, was understood to be the first female director of hard core porn movies in the UK when she began her directing career in 1998 (see Purton, 11 March 2010). Men dominate the oldest profession, very possibly for the same reasons that they dominate serious professions such as medicine and academia.

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Sex Differences in Intelligence: Developmental Origin Yes, Jensen Effect No

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Richard Lynn's developmental theory of sex differences in intelligence is evaluated using the administration of the Armed Services Vocational Aptitude Battery in the NLSY79. Score increases between age 15 and age 23 are found to be greater in males than in females, supporting an essential element of the theory. On the other hand, neither the sex differences themselves nor their developmental changes are related in any consistent way to the *g* loadings of the subtests. Therefore sex differences should not be conceptualized as differences in "general" intelligence (*g*).
Key Words: ASVAB, NLSY, Intelligence, Sex differences, *g* loadings, Development

The theory outlined by Richard Lynn in his target article makes two important testable assumptions. First, it proposes that there are cognitive sex differences that can be conceptualized meaningfully as differences in general intelligence. The concept is operationalized either as an IQ calculated as the average (or, more bombastically, a "unit-weighted factor score") of subtest scores on a complex test battery such as the Wechsler tests, or as the unrotated first factor or first principal component from a factor analysis or principal components analysis on the subtest scores. The second claim is that sex differences are age-dependent, with minimal and inconsistent differences in childhood and a male advantage developing gradually from about age 15 or 16. This developmental trend is assumed to be related to the later timing of puberty in males than females, which is associated with later and more prolonged male brain maturation as well as physical maturation. In the following, I will examine these claims using the 1980 administration of the Armed Services Vocational Aptitude Battery (ASVAB) in the National Longitudinal Survey of Youth 1979 (NLSY79).

Materials

1. The NLSY79 sample

The National Longitudinal Survey of Youth was launched as a prospective longitudinal survey by the US Department of Labor in 1979. Subjects aged 14-22 years were enrolled. The sample is not entirely representative of the US population because those from lower socioeconomic backgrounds and some ethnic/racial minorities were oversampled. However, males and females were sampled in proportion from each group. The Armed Services Vocational Aptitude Battery (ASVAB) was administered to the entire cohort in 1980. Complete test results are available for 5975 males and 5939 females.

2. Properties of the ASVAB

The ASVAB is a vocational aptitude test that is used for screening of prospective recruits and for assignment to diverse military duties and training programs in the US armed forces. It is composed of 10 subtests:

1. *General Science:* Knowledge of physical and biological sciences.
2. *Arithmetic Reasoning:* Word problems that emphasize reasoning rather than mathematical knowledge.
3. *Word Knowledge:* Understanding the meaning of words.
4. *Paragraph Comprehension:* Understanding the meaning of paragraphs.
5. *Numerical Operations:* A speed test of mental addition, subtraction, multiplication and division.
6. *Coding Speed:* A speed test to match words and numbers.
7. *Auto and Shop Info:* Knowledge of automobiles, shop practices and use of tools.
8. *Mathematics Knowledge:* Knowledge and skills in algebra, geometry and fractions.
9. *Mechanical Comprehension:* Understanding of mechanical principles such as gears, pulleys and hydraulics.
10. *Electronics Info:* Knowledge of electricity, radio principles and electronics.

These descriptions of the subtests are from Maier & Grafton (1981). Psychometrically, the ASVAB is a test of crystallized intelligence: acquired knowledge and skills rather than context-free reasoning ability. As such, it is closely related to tests of literacy (Marks, 2010).

3. Scaling of scores

Because scores on all subtests increased with age in an approximately linear fashion, the subtest raw scores were residualized for age and scaled to the IQ metric, with a mean of 100 and standard deviation of 15. Principal components analysis of these age-residualized scaled scores produced an unrotated first principal component (*g* factor) accounting for 66.1% of the total variance. This *g* factor, scaled to the IQ metric, was used as a measure of general intelligence.

Results

1. The (un)importance of g

Table 1 shows the *g* loadings (correlations with *g*) of the scaled subtest scores, and the male and female means and standard deviations on each subtest and the *g* factor. The scaling implies that because of the nearly equal numbers of males and females, male and female scores average out to 100. Because of the large sample sizes almost all sex differences (*d*) are statistically significant. Therefore interpretation of the results should be based on the magnitude of the differences rather than their statistical significance.

Table 1. g *loadings of ASVAB subtests, and sex differences. N = 5,975 males and 5,939 females. d = standardized sex difference: (♂ mean - ♀ mean) / averaged standard deviation; ** p<.01; *** p<.001, two-tailed. Δ age trend is the extent to which males gain more than females per year, expressed on the IQ scale.*

	g loading	♂ mean ± SD	♀ mean ± SD	*d*	Δ age trend
1. Science	0.887	102.0±15.9	98.0±13.8	0.27***	0.229
2. Arithmetic	0.872	101.5±15.5	98.5±14.3	0.20***	0.354
3. Words	0.891	99.8±15.4	100.2±14.6	-0.03	0.112
4. Comprehension	0.839	98.6±15.4	101.4±14.5	-0.19***	0.294
5. Numerical Ops.	0.737	98.3±14.9	101.7±14.9	-0.23***	0.587
6. Coding	0.673	96.9±14.3	103.1±15.0	-0.42***	0.286
7. Auto & Shop	0.732	106.7±15.6	93.3±10.7	1.02***	1.029
8. Math knowledge	0.833	100.4±15.4	99.6±14.6	0.05**	0.458
9. Mechanical Compr.	0.806	104.7±15.9	95.3±12.3	0.67***	0.707
10. Electronics Info	0.830	104.5±15.7	95.5±12.7	0.63***	0.518
g		101.7±16.0	98.3±13.8	0.23***	0.549

The results confirm that males do indeed have higher *g* than females. However, we also see that sex differences on 5 of the 10 subtests are larger, and in some cases far larger, than the differences in *g*. Average *absolute* sex differences are 0.37*d* (5.6 IQ points) on the subtests, as opposed to 0.23*d* (3.5 IQ points) on the general factor. This is not expected if the sex differences are only or even mainly on *g*.

Another prediction of the hypothesis that sex differences are mainly on general intelligence is that the sex differences favoring males are larger on those tests that are the best measures of the general factor, meaning those that correlate best with *g*. The actual correlation of the subtest *g* loadings with the *d* values is +.142, which is in the expected direction but not nearly significant: essentially, a null result. Inspection of the ASVAB subtests shows the nature of the sex differences. There are five tests with primarily academic content: Science, Arithmetic, Words, Comprehension, and Math Knowledge; two tests of psychomotor speed: Numerical Operations, and Coding; and three tests of vocational knowledge and skills: Auto & Shop Info, Mechanical Comprehension, and Electronics Info. Sex differences favor males on the vocational tests, females on the speed tests, and sex differences are small on the academic tests.

Because it can be argued that the vocational subtests are related to specific experiences and knowledge that men are more exposed to than women, let's see what happens to the sex differences when these three tests are omitted. In that case, the remaining 7 subtests produce a *g* factor on which females outscore males by 0.8 IQ points. However, this time the correlation between *g* loadings and sex differences is +.693, which comes close to conventional statistical significance ($p=.084$). This suggests that males tend to do better on highly *g*-loaded tests, and females do better on tests with lower *g* loadings.

However, we can also argue that psychomotor speed is conceptually different from intelligence. In dual-processing theories of cognition, quick responses require automatic processing while intelligence is a property of a slow processing system (Evans, 2008). What happens to sex differences when the two speed tests are removed but all others are retained? As expected, the male advantage on the *g* factor extracted from the remaining eight subtests is enhanced: from 3.4 points in the complete ASVAB to 5.2 points when the speed tests are deleted. In addition, the sign of the correlation between *g* loadings and sex differences reverses, to -.447. Thus the answer to the question of whether tests with higher *g* loadings favor males or females depends very much on the composition of the test battery.

2. Changes with age

Let us now examine the developmental trajectory that is proposed by Lynn's theory. Table 2 shows how sex differences on the general factor, extracted from all 10 subtests, change with age. There is no sex difference at age 15, but males pull ahead of females as they get older. At age 20 and beyond they outscore females by almost one third of a standard deviation, or 5 IQ points.

Table 2. *Sex differences on the general factor extracted from the ASVAB subtests, by age. d = standardized sex difference: (♂ mean - ♀ mean) / averaged standard deviation.*

Age	♂ mean ± SD	♂ N	♀ mean ± SD	♀ N	*d*
15	99.7±14.6	488	100.3±12.7	431	-0.04
16	101.6±15.2	784	98.5±12.6	725	0.22
17	102.0±16.1	750	98.8±13.0	752	0.22
18	100.8±16.0	705	99.0±13.3	721	0.12
19	100.4±16.7	761	97.5±14.0	757	0.19
20	102.4±16.3	741	97.5±14.4	813	0.32
21	103.4±16.1	751	99.0±14.2	774	0.29
22	102.0±16.2	765	97.2±14.9	798	0.31
23	102.9±15.2	230	96.7±14.2	168	0.42

We saw before that, ignoring age, the pattern of sex differences on the subtests shows no consistent relationship with the subtests' *g* loadings. It is nevertheless possible that, for example, prenatal androgen action creates the strengths and weaknesses of the sexes on specific subtests while continued brain development after the age of 15 years creates an omnibus male advantage that is strongest on tests with higher *g* loadings. To test whether the greater male than female improvement in test performance after age 15 is related to the subtests' *g* loadings, simple regressions were performed predicting subtest score with age, separately for males and females. The unstandardized B coefficients were recorded for each regression, and the female B coefficient was subtracted from the male B coefficient. This difference score is taken as the difference in score gains between males and females, expressed as IQ points gained or lost per year.

The last column in Table 1 shows the results. On each subtest and the common factor, the signs are positive indicating that the increase in performance with rising age is greater in males than in females. The extent of this sex difference is smallest for Word Knowledge, where it amounts to 0.112 IQ points per year. This means that between the ages of 15 and 23 years, males gain 0.112 * 8 = 0.896 points relative to females. At the other extreme, male gains on Auto & Shop Info exceed female gains by as much as 8.232 points. In other words, between these ages males and females acquire new word knowledge at similar rates, but males acquire auto and shop knowledge at much higher rates than do females. Gains on the other subtests are in between, and between the ages of 15 and 23 years males gain 4.39 IQ points relative to females on the common factor.

When the sex difference in score gains in the last column of Table 1 is correlated with the *g* loadings of the subtests, we obtain a Pearson's *r* of -.492, which is non-significant. As before, we can exclude the vocational tests and the speed tests from the analysis. Without the three vocational tests we obtain $r = -.357$, and without the two speeded tests we obtain $r = -.785$. The last of these correlations is statistically significant at $p = .021$ with a sample size of 8 tests. The negative signs of these correlations show that, if anything, the extent to which score gains of males outpace those of females between the ages of 15 and 23 years tends to be greater on tests with lower *g* loading. This contradicts the view that males gain on females in *general* intelligence during late adolescence.

A look at the first and last data columns in Table 1 shows the reasons for the negative signs obtained in this exercise. We see that the vocational tests are those on which males gain much faster than females in late adolescence. These tests have *g* loadings that are rather low (Auto & Shop Info) or middling (Mechanical Comprehension, Electronics Info). After excluding the vocational tests, the low-*g* speeded tests show somewhat greater male-versus-female gains than the academic tests; and when the speeded tests are excluded but the vocational tests are retained, there is a fairly consistent pattern of vocational tests having larger male-versus-female gains with age while also having somewhat lower *g* loadings.

Conclusions

The results presented in this comment illustrate two aspects of Richard Lynn's developmental theory of sex differences in intelligence. The first is that sex differences are small and/or variable up to the age of about 15 years but that males tend to pull ahead of females after that age. This part of the theory is supported, as indicated by the *d* values in Table 2. Even the final magnitude of the sex difference, of nearly 5 IQ points, agrees well with results from many other studies compiled by Lynn. Furthermore, there is some generality to the greater male than female gains between the ages of 15 and 23 years, in the sense that these are observed on all subtests (last column of Table 1).

On first sight, the results confirm Lynn's conclusion that in adulthood, males outscore females by 4 to 5 points in general intelligence. However, a closer look at the results shows that the male advantage on the ASVAB is due to the presence of three subtests that concern vocational skills and knowledge. Without these three tests, the sex difference is virtually zero. Even in the 20-23 years age group, where males outscore females by 4.8 points on the complete test, they score only a negligible 0.3 points higher than females when the vocational tests are omitted. Furthermore, there is no consistent relationship between the *g* loadings of subtests and their sex differences. Sex differences do not show a Jensen effect. Spearman's hypothesis, which proposes that score differences between racial and ethnic groups are largest on the most *g*-loaded tests (Jensen, 1985), does not apply to sex differences. Therefore sex differences cannot be explained as differences in a general ability factor, but only as differences in specialized abilities, at least for the range of abilities that are tested with the ASVAB.

Also the sex differences in subtest score gains, presented in the last column of Table 1, do not show a Jensen effect. This sex difference is general only in the sense that males gain faster than females on all subtests, but it cannot be conceptualized as *g*. Specifically, we observe that the extent to which yearly gains are greater in males than females is most pronounced on the three vocational tests and on numerical operations (mental arithmetic). This suggests that accelerated male development in these domains is not only the result of faster overall brain maturation, which would presumably affect all abilities in proportion to their *g* loadings. It is better explained by content-specific factors such as greater male than female exposure to or interest in tools, engines, gears, hydraulics and numbers.

On the other hand, we observe that male gains with age exceed those of females also on the other ASVAB subtests. This indicates that there is a general component to the sex difference in cognitive trajectories during late adolescence, although this general component cannot be conceptualized as *g*. We saw that on the *g* factor extracted from all 10 subtests, this difference in developmental progression accounts for 4.39 IQ points between the ages of 15 and 23 years. When the *g* factor is extracted from the seven non-vocational subtests only, this developmental difference is reduced to 3.13 points. These results suggest that the true developmental component in Lynn's developmental theory amounts to approximately 3 IQ points that males gain on females between the ages of 15 and 23 years, at least on a composite of those abilities that are tested with the ASVAB.

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Sex Differences in Self-Estimated Intelligence, Competitiveness and Risk-Taking

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Studies of self-estimated intelligence have consistently shown that males estimate their intelligence higher than do females, and people estimate the intelligence of male family members higher than that of female family members. A number of studies have also shown that males are more competitive and greater risk-takers than females.
Key Words: Sex differences, Self-confidence, Intelligence

Richard Lynn has written a convincing, thoroughly empirically based paper in one of the “hottest” areas of psychology. To suggest there are group differences in intelligence will cause more “debate” than practically any other issue in psychology. He is well known for his courageous stand, always based on hard data.

I want to add two comments to the debate. Presuming that males are “somewhat” more intelligent than females, the question is how this translates into the obviously greater success of males than females in so many areas of life such as creativity in the arts and sciences, as well as in business. Whilst there are numerous sociological arguments to “explain” this situation, I want to suggest two further points related to his paper.

The first concerns intellectual self-confidence or self-estimated IQ. I have published many papers and have data from 30 countries from Argentina to Zambia that suggests there is a universal finding that men estimate their own IQ as 3-10 points higher than females (e.g. Furnham, 2000; Furnham & Bunclark, 2006; Furnham & Shagabutdinova, 2012; Szymanowicz & Furnham, 2011). Lynn would no doubt argue that this reflects reality, though others of course would argue that it is because of their socialization: Boys are encouraged to brag about and girls to hide their intelligence. Whatever the cause, there are few studies from any country that do not support the finding that males estimate their IQ, understood as "general intelligence" rather than "multiple intelligences", higher than do females.

Whether this difference reflects an actuality or not, there is considerable evidence that self-beliefs can be self-fulfilling. To quote Henry Ford: *"Whether you think you can, or you think you can't—you're right."* Thus it may be that male achievement in so many aspects of life can in part be attributed to their self-belief in their intelligence which may (or may not) accurately reflect their actual ability. In a study at the University of Oxford, three female dons led by Jane Mellanby showed that consistent male domination of the top marks was due mainly to academic self-confidence (Mellanby, Martin & O'Doherty, 2000). Thus self-belief, whatever it is based on, has manifold consequences.

A question which arises from the self-estimated intelligence literature is whether the sex difference, if not real, is due to male hubris or female humility. Do males over-estimate or women under-estimate their actual IQ, or both? There are not enough good studies with both self-estimated and test-derived IQ to settle the argument.

The second issue is competitiveness vs cooperativeness, and general risk-taking. There is a considerable amount of data from evolutionary and social psychology to suggest that males are more competitive than females. Again, there is a dispute as to whether this difference is predominantly biologically based or the product of socialization, but there are numerous studies to support this effect. Males are more competitive, and females are more cooperative.

Further, this competitiveness is linked to risk-taking. It is for this reason that males tend to be more involved in accidents and in entrepreneurial, criminal and military adventures. Thus, if males are more desirous to succeed (achievement orientation), willing to put in the effort, *and* risk a great deal in the process, it is not surprising that they have a greater success rate in many fields including the achievement of academic competence, which requires the development of high intelligence.

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Sex Differences in Intelligence: A Genetics Perspective

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Richard Lynn's paper on the existence and the magnitude of sex differences in general intelligence proposes that among adults men have a higher average IQ than women and greater variability, and these contribute to the greater number of men among high achievers. The greater variability of males may be attributable to X-linked transmission of intelligence and/or to higher testosterone that could increase the expression of genes related to neurological development or cognition.
Key Words: Intelligence, Sex differences, X-linked inheritance

The focus of Richard Lynn's paper on the existence and the magnitude of sex differences in general intelligence or IQ deserves more consideration than it has gathered so far. Lynn proposes that age mediates sex differences in intelligence, and contends that this variable has been ignored by studies of this phenomenon. Specifically, whilst intelligence stops increasing in girls after puberty, in males it would seem to continue on its developmental path for a few more years. There is a parallel to this in front of everybody's eyes: human height, a trait that shares many statistical properties with IQ such as polygenic inheritance and following a normal distribution. Although height behaves in a more dramatic fashion, large differences between boys and girls do not start appearing until they reach an age of 12-13 years and only the boys continue to grow until (and in some cases into) adulthood, whilst girls typically stop growing when they are 15-16 years old. What Lynn advances is an ingenious solution to the inconsistency of findings across research groups and could elucidate the biological mechanisms responsible for the development of intelligence along the lifespan.

A few claims around sex differences in cognition are not very controversial and they are less disputed than the contention put forward by Lynn. One of these is the widely accepted finding that males exhibit higher variability of intelligence than females (Lubinski & Benbow, 2006; Wai et al., 2010). In the real world, higher variability implies that there are more male geniuses and more intellectually disabled men than women. Higher variability in one sex is usually associated with the X-linked transmission of a trait. Females get two copies of the X chromosome (one from each parent), but males inherit only one. Therefore any recessive mutation present on the X chromosome will translate into phenotypic effects much more frequently among men, who express the gene at the phenotypic level when they possess only a single copy of it. Typical examples of sex-linked inheritance are color blindness and Duchenne muscular dystrophy. X-linked inheritance of intelligence has been proposed by some researchers (e.g. Lehrke, 1997).

Contrary to common misconceptions, X-linked recessive alleles are not necessarily deleterious. It is possible that the X chromosome harbors alleles that increase intelligence, in addition to mutations that have deleterious effects on brain maturation and cognition. The X-linked theory of intelligence does not predict higher male intelligence. It rather predicts greater male variability, because when an X-linked polymorphism has a high-IQ allele and a low-IQ allele, the male will show either the high-IQ or the low-IQ phenotype whereas a heterozygous female is more likely to be intermediate.

Greater male variability implies the possibility of bias when the sample has range restriction or the intelligence test has floor effects or ceiling effects. If individuals with extremely low IQ (who more likely are male) are underrepresented in the sample, this would introduce a bias favouring males. Conversely, underrepresentation of individuals at the high end of the distribution would introduce a female bias. The same effect is encountered when the test has floor effects (test too difficult, cannot discriminate among low-ability individuals) or ceiling effects (test too easy, cannot discriminate among high-ability individuals). When the sample is representative but the test has floor effects, it will produce higher mean (though not median) male than female scores because it cannot distinguish among those at the low end (more often male); and if the test has ceiling effects, it is predicted to produce higher female than male mean scores because it cannot distinguish among those at the upper end (more often male). A re-analysis of the literature is needed with emphasis on the issue of range restriction, although Lynn's present study dealt with this issue and found sex differences in intelligence also for tests with no significant range restriction.

It should be noted that genome-wide association studies (GWAS) almost always include only the autosomal genome, hence a test of the sex-linked inheritance of intelligence at the molecular level is at present impossible. If X-linked inheritance were important, this could partially explain why the factor scores and polygenic scores computed from GWAS hits can account for very little of the phenotypic variance in IQ: only around 5% in Sniekers et al. (2017) and 4% in Davies et al. (2017).

Another mechanism to account for sex differences in intelligence, which is not mediated by the sex chromosomes but rather by the autosomal chromosomes, is called sex-influenced inheritance. It explains the different patterns of expression of the same genes in males and females. Examples are the antlers of male deer, and baldness in humans. This theory has the advantage of potentially accounting both for higher variability and higher male average scores. Another practical advantage is that this hypothesis can be tested using GWAS of intelligence or educational attainment. In fact, these commonly report effect sizes for males and females separately. If some genes or SNPs (single-nucleotide polymorphisms) will be found to affect disproportionately females or males (i.e. showing significant cross-sex inconsistency in beta coefficients), this would provide evidence (though not proof) for differential expression of the genes by sex.

In most cases, sex-influenced inheritance is caused by sex hormones. These hormones activate transcription factors, which means they act specifically by regulating the expression of genes. If testosterone were found to increase the expression of genes related to neurological development or cognition in general, this fact could potentially explain both higher male variability and higher average male scores. Higher male variability would be predicted by overexpression of cognition-related alleles, both detrimental and beneficial ones. Conversely, higher male scores would depend on over-representation of beneficial alleles sensitive to testosterone. According to this model, different sensitivity of individuals to sex hormones and different levels of hormone secretion could cause differences between individuals in cognitive performance. Importantly, sex-influenced inheritance would be consistent with Lynn's developmental theory of sex differences in intelligence, because traits that show differential maturation during and after puberty are under the control of sex hormones, for example stature (MacGillivray et al., 1998). The prolonged growth in stature of males compared to females is well documented by growth charts (e.g.: https://www.cdc.gov/growthcharts/clinical_charts.htm) in many different countries. The average 15-year-old girl grows by another 1cm, and the average 15-year-old boy grows by another 7cm. Perhaps it is time that intelligence is studied from a developmental perspective not only in childhood, but also well after puberty. Researchers would then compile accurate and detailed longitudinal growth charts for intellectual as well as physical development.

Another well-established finding which attracts little controversy is that of sex differences on specific abilities such as processing speed (favoring women) or mental rotation tasks (favoring men) (Ellis, 2008). There is evidence that these abilities are influenced by testosterone (Gouchie & Kimura, 1991; Janowsky et al., 1994; Resnick et al., 1986). These phenomena point to the presence of sex-influenced mechanisms of inheritance in cognitive abilities and do not preclude extension of the same mechanisms to higher-order constructs such as IQ or general cognitive ability. Future research will have to explore this issue in depth, using molecular data from both autosomes and sex chromosomes. Twin studies can also shed light on this issue by comparing genetic correlations between same-sex and opposite-sex twins. Lower opposite-sex genetic correlations suggest the involvement of genes with sex-specific effects (Jelenkovic et al., 2016).

It is to be hoped that Richard Lynn's theory will kick-start research into intelligence from a developmental angle, with accurate description of longitudinal growth patterns, and from a biological perspective, with more attention paid to hormonal or sex-dependent modulation of gene expression and to the sex chromosomes in genome-wide association studies.

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Presumption and Prejudice: Quotas May Solve Some Problems, but Create Many More

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Some Western countries contemplate, or have already implemented, legislative means to counter group differences. Here, I consider the arguments for, and consequences of, sex quotas. I find that it is logically incoherent to impose selection based on group membership, such as quotas, unless one acknowledges that there is a group difference in some trait that affects the outcome in the domain in which the selection takes place. If such a group difference is acknowledged, a quota might decrease the proportion of individuals who are more likely to have undesirable traits that are difficult to measure. However, the fact that traits are normally distributed and overlap across groups means that it is more effective to select for desirable traits than for group membership. Also, quotas inevitably entail negative consequences that should be weighed in. From the perspective of the individual, it is fairer to be selected on the basis of traits one actually has, rather than a stereotype of the group one belongs to. From the perspective of society as a whole, focusing on group differences and selecting based on group membership is divisive and conflict-driving. It stirs hostility by encouraging competition over resources and social status between groups instead of between individuals. These arguments and conclusions are applicable to other groups and group differences in general.

Key words: Affirmative action; Cognitive ability; Intelligence; Interests; Sex differences; Quotas; Equal opportunity; Legislation; Sweden

Western societies cultivate a rhetoric about decreasing differences in outcomes between groups of humans, to be achieved by social interventions such as redistribution through taxes, affirmative action, and quotas. The purpose of this article is to clarify central issues relevant to this tendency, and to discuss the effectiveness and other unintended consequences of doing so. I will focus on sex differences, in accord with the theme of this special issue, but the same reasoning may be applied also to other groups.

I have always assumed that men and women are psychologically identical. This is probably because this is ingrained in Swedish culture. For example, I have never come across any mention of heritable or biologically influenced sex differences in my curricula, including university. It was only when challenged by sex differences in my own research data that this assumption began to crumble, as I was forced to read up on the literature on human sex differences and evolutionary psychology. I found an impressive consilience in terms of empirical support for elaborate and detailed predictions based on evolutionary theory, which is outside the scope of this article (for introductions and reviews, see Browne, 2002; Buss, 1995, 2016; Buss & Malamuth, 1996; Campbell, 2002; Ellis et al., 2008; Geary, 2010; Swami, 2011; Trivers, 1972). Suffice to say that substantial behavioral, physical, and often cognitive sex differences are found in virtually every sexually reproducing species, which have largely evolved through sexual selection (Andersson, 1994). It is extremely unlikely that humans would for some reason be exempt from sexual selection, or would for some extraordinary work of chance have all those sex-dimorphic traits balanced that happen to be relevant for competence in modern Western societies.

Indeed, psychological sex differences across a broad range of traits are universally recognized in folk psychology world-wide (Löckenhoff et al., 2014), and many of these are empirically found to be universal across cultures (e.g., Cross, Copping & Campbell, 2011; Else-Quest, Hyde & Linn, 2010; Lippa, 2009, 2010b; Lippa, Collaer & Peters, 2010; Schmitt et al., 2003, 2004, 2008; for a review, see Geary, 2010). Thus, the default expectation is for there to be sex differences in outcomes, as even traits remote to reproduction-related activities are likely to be affected by hormonal differences during the whole course of ontogenesis (Dorn et al., 2009; Vermeersch et al., 2008).

That being said, it is also the case that exactly predicting real-world outcomes from psychological sex differences is extremely difficult. Nevertheless, such predictions are essential both for evaluating whether selection of individuals into modern contexts, such as school and work, is biased, which is the central argument for quotas, and for predicting effects of selection based on quotas. For the present purpose, it is necessary to know some basic facts about sex differences in both psychological traits and outcomes, so I will provide a brief overview of the main findings. The most important traits for success in the labor market will also be mentioned, as well as prejudice and stereotyping. Finally, I will bring these strands together in a discussion of the arguments put forth by quota advocates and the consequences of applying them. First, however, it is useful do define the central concept of selection.

1. Selection and quotas defined

Selection is here understood as choosing one individual over another for a task or a position of any kind. Typically this includes jobs, education, and positions of trust, such as chairpersons and board members in private companies, NGOs, and civil organizations within and outside governmental or communal authorities. The main purpose of selection is to maximize success, primarily based on the competence of the selectee. Competence may of course include anything that arguably contributes to success in the position, including such things as orderliness and interpersonal skills.

In contrast, a quota is the selection of individuals based on a demographic category or group membership according to quantitative goals, such as selecting a certain proportion or reaching a certain proportion of that category. Such measures are sometimes called ‘equal opportunities promotion’ or ‘affirmative action’, although the latter is defined as steps to reduce discrimination (Kirkpatrick et al., 1987). A characteristic of such measures is that group membership trumps whichever selection criteria may be related to the individual’s performance in the selected position. By logical extension, the function of quotas is thus to select a less qualified person over a more qualified one: If meritocratic selection would lead to the desired proportion of individuals from different groups, quotas would serve no purpose.

2. Sex differences in traits and in educational and occupational outcomes

According to the literature, the most important traits for occupational success are intelligence and the personality dimensions agreeableness and conscientiousness (e.g., Gottfredson, 1997, 2002; Perkins, 2016). Women are more agreeable and conscientious than are men, with effect sizes on the order of 0.2-0.3 (Schmitt et al., 2008). However, the sex differences are considerably larger for certain subscales, such as anxiety, assertiveness, and tendermindedness (Feingold, 1994). Moreover, multivariate analyses that take all items or facets into account, rather than averaging across them, have reported effect sizes close to 1.0 (Del Giudice, 2009; Verweij et al., 2016) and 2.7 (Del Giudice, Booth & Irwing, 2012). This means that the sex difference in the constellation of personality traits is much larger than the difference on any single trait. In addition to personality proper, men are more impulsive, risk-taking, and sensation-seeking (effect sizes 0.35–0.5), as well as less harm-avoidant (effect size 0.8) (Cross et al., 2011; Ellis, Hoskin & Ratnasingam, 2016). Individual differences in these traits are explained in part by prenatal and postnatal exposure to androgens, for example about 15% for risk-taking (Ellis et al., 2016, Table 7; Geary, 2010, ch. 8; Sapienza, Zingales & Maestripieri, 2009).

As the present volume demonstrates, there are also sex differences in cognitive ability, with women typically scoring higher on verbal and episodic memory and processing speed, and men on spatial ability, motor speed and mathematical reasoning, for example (for reviews, see Cahill, 2017; Ceci & Williams, 2011; Gur & Gur, 2017; Halpern, 2012; Kimura, 1999). Across multiple subtests, these differences typically produce a *g* factor or a full-scale IQ difference on the order of 2-4 IQ points, which seems to be remarkably consistent across studies (Irwing, 2012; Lemos et al., 2013; Lynn, Chen & Chen, 2011; Madison, 2016; Piffer, 2016) and related to brain volume (Colom et al., 2000; van der Linden, Dunkel & Madison, 2017). It is also well established that the wider distribution of intelligence amongst males alone leads to several men for each woman in the right tail of the IQ distribution (Deary et al., 2003; Johnson, Carothers & Deary, 2008), which is thus amplified by the small mean difference. Recent reviews report a stable male-to-female ratio on the order of ~1.1-1.3 for the top 1 percent and ~3.4-4.1 for the top 0.01 percent on the SAT across the last 25 years (Makel et al., 2016; Wai et al., 2010).

Men also tend to display a higher drive for status (for a review see, e.g., Buss, 2016) and women tend to have higher demands than men regarding safety, such as permanent positions, predictable career development, and avoidance of dangerous or harmful conditions, as well as fewer work-hours and less time away from family and friends (Browne, 2002; Pinker, 2008). This pattern is consistent with evolutionary theory, including parental investment (Buss, 2016).

It should be stressed that all psychological traits are normally distributed, within as well as across the sexes. There is thus no support for essential, qualitative differences, so-called gender essentialism (Butler, 2006). Rather, there will be a significant proportion of women that is more “masculine” in any particular trait than the average male, as well as a proportion of men that is more “feminine” than the average woman. Hence there is always an overlap proportion of both sexes who share the same range of levels in that trait.

Possible consequences of the sex differences just reviewed depend on the match between the mean level in the population and the required level for each type of job or position. Sex should play a minor or insignificant role for positions whose required level falls short of the population mean of each sex, but should have a substantial influence on the selection for positions with very high requirement levels. Regarding personality traits, risk-taking, and harm avoidance, this would seem to be consistent with the male dominance in finance, construction, crime, the military and the police, and in jobs in general which incur discomfort and high risks for physical or psychological harm. It seems likewise to be commensurate with the strong dominance of women in professions that involve caring and personal relations, such as kindergarten and school teachers, nurses, counsellors and physicians. The pattern of cognitive abilities seems to be consistent with the male dominance in domains such as chess, mathematics (Lubinski & Benbow, 2007; Robertson et al., 2010), and STEM in general (Peers, 2016), as well as the female dominance in professions that require high levels of dependability and orderliness, such as auditor, manager, and administrative tasks in general.

Regarding outcomes in the sex ratios among different domains, Sweden is an example of a society that has long ranked amongst the few most sex-egalitarian countries in the world (World Economic Forum, 2015). In Sweden, the proportion of women in university education is more than 80% for health care and teaching, 60% for the humanities, social sciences, law, and business and administration, 40% for the natural sciences, and 30% for technology and engineering (Statistics Sweden, 2014). In the labor market, it is 90% for the health care sector, 76% for primary teachers, 65% for school principals, 58% for shop clerks, 39% for data systems designers, 6% for lorry drivers, 2% for electricians, and 1% for carpenters (Statistics Sweden, 2014). Similar trends are found world-wide (Lippa, 2010a,b), and are consistent with the people-things dimension (e.g., Baron-Cohen, 2003), which is empirically found to explain variance in educational (Su & Rounds, 2015) and vocational choice (Beltz, Swanson & Berenbaum, 2011; Manning et al., 2010; Nye & Orel, 2015).

3. Predicting outcomes from traits: the indetermination problem

Although the present review shows a high level of correspondence between traits and outcomes, it does not prove that the former, in fact, cause the latter. For implementing interventions, it is critical to be able to make precise predictions, as it is the only basis on which we can evaluate their effects. There are at least four major problems with predicting success or sex ratios from sex differences in psychological traits.

First, it is a truism that any trait plays out its effects in interaction with the environment, which potentially forms an infinitely complex web of relationships. For example, women constitute 30% of the engineering workforce in Latvia but only 9% in the UK. This reflects a trend that the lower proportions, around 15%, are found for relatively rich countries with strong welfare systems and a long history of democracy in Western Europe, and the higher proportions, around 25%, for poorer countries with less exposure to democracy, including some from the former Soviet bloc (Peers, 2016). This trend is found for other outcomes as well, such as women's proportion of academics and corporate management (World Economic Forum, 2015). One mechanism that has been proposed to account for these national differences is that individuals in richer countries are able to choose their path more in line with their interests and preferences, and less in consideration of remuneration and other material rewards (Pinker, 2008). As support for this, Pinker notes that countries with the highest indicators of sex equality tend to have the most sex-segregated academic sector (Stoet & Geary, 2015) and labor market (e.g., Charles & Bradlesy, 2009), contrary to the idea that greater freedoms would lead to less segregation.

Second, there is obviously a host of factors that interact with individual traits, and which account for a large share of the total variance in outcomes with respect to sex. When we consider all the environmental factors that operate on geographical, regional, and socioeconomic levels, and so forth, the sheer complexity renders precise predictions unfeasible.

Third, any prediction or other analysis is limited to the factors we choose to include, whether they are intentionally selected or happen to have been measured in the particular dataset. The influence of factors that are not included in the analyses remains undetected and hence unknown.

Fourth, it is principally impossible to achieve sufficient control in a real-world context, and conclusions regarding specific effect sizes and causal relationships will therefore remain tentative even for the factors included.

These limitations can be handled in a multitude of ways, and should not deter one from conducting the research. But if the resulting knowledge is to be used prescriptively, such as for motivating quotas, it seems appropriate to require a standard close to "beyond reasonable doubt". This is because interventions necessarily have some bad consequences that ought to be weighed against the good ones. Without accurate and careful pre-treatment predictions of the consequences, it may well be that the good ones fail to materialize, that the bad ones exceed expectations, or that unexpected bad ones emerge. Even post-treatment evaluations will be inaccurate because of the impossibility of weighing in all the complexities just reviewed, as well as concurrent secular changes in society.

4. Stereotyping

Stereotyping refers to attributing features to a demographic category, and hence to any individual from that category. It has been widely claimed that stereotypes are incorrect, and even that they are arbitrarily assigned in order to maintain social power structures. The evidence for this is weak, however, and the most comprehensive reviews and critical analyses indicate that stereotypes are essentially correct, in that they predict very well average traits on the basis of group membership (Jussim, 2012; see also Jussim, 2017; Jussim et al., 2015; Löckenhoff et al., 2014). Even so, stereotyping and prejudice in general remains of course a potential problem for the individual, as the stereotype might not be a good representation of their preferences and abilities. The more she differs from the typical for her sex, the more the expectations about her are likely to be incorrect.

One type of solution that is suggested in the popular and political debate is to dispense with stereotypes altogether. Inasmuch as prejudices are correct perceptions and abstractions of reality, often based on personal experience, this would not be possible. The human brain is set at predicting the environment by building models of it, constantly discovering systematic regularities to this end (Frith & Frith, 2011; cf. Miall et al., 1993). This is, of course, highly adaptive (Seligman, 1970). These predictions are constantly used in everyday life. Without them we would suffer considerably, if not fatally. Another point to consider is that social expectations are double-edged. Just as they might harm an individual by not allowing her to prove herself in the context of a position, for example, they might favor her by more easily exceeding a lower set expectation, according to the shifting-standards model (Biernat, 2003).

Another claim is that stereotypes actually cause individuals to become more similar to the expectations for the group they belong to, an extension to the general social multiplier effect (Dickens & Flynn, 2001). I have not reviewed the empirical support for this claim, but it may well be the case. A cross-cultural comparison suggests, in contrast, that less stereotyping is associated with more stereotypical behavior (Lippa et al., 2010). Reasonably, however, the extent of this effect depends on the level to which individuals actually identify with a particular group, and on the values that a society holds regarding individualism contra collectivism. Western societies tend to be considerably less group-oriented and collectivistic than most other societies (Welzel, 2013). If some individuals to some extent toe the line of what they perceive to be typical of the group they identify with, that is their personal choice. It is not something that the state or civil society should interfere with, as manipulating accurate expectations about the world is counterproductive and potentially dangerous to the individual (cf. Madison & Ullén, 2012).

5. Discussion

I have argued that selection should be based on competence, reviewed some psychological sex differences that seem particularly relevant for success in the education and labor markets, and mentioned some problems with stereotyping. A critical point has been that the indetermination problem essentially prevents the evaluation of interventions based on group membership, such as quotas. I will now consider some common claims in the public debate about quotas.

The first is that we are currently on a track towards greater similarity or equality between the sexes, only the rate of which can be affected by our actions and thoughts. For example, a Swedish parliamentary bill from 2013 states that:

> "… debaters have long resisted a law about quotas, arguing that those selected by quotas risk being challenged. That argument does not hold water, and more people realize that quotas is an effective method. For us, quotas is no political goal in itself, but could be a means to reach a goal. We wish it were not needed but when the years pass by and nothing happens we cannot just "wait and see"..." (Ericson et al., 2013, my translation).

This seems to reflect a very naïve view, in light of the available research. Quota advocates tend to assume that attitudes and norms largely determine the current segregation by sex, and that social forces are currently pressing ahead to change these norms in the direction of increasing the proportion of women. This is akin to the idea that the proportion of an "underrepresented" demographic category must first be increased by force until it reaches a "critical mass", after which it will be able to sustain itself (Ridgeway & Lovin-Smith, 1999).

A more accurate view is that the present situation reflects the interaction between biologically influenced traits and environmental factors. History records dramatic changes in the roles of men and women, which cannot be altogether biological, at the same time as some sex differences remain consistent across time. The nature of groups of people is not determined by their state in 1900 or 1800. Economic, material, technical, and social conditions have changed dramatically in the last 200 years, as well as in the last 50 years alone. Indeed, the whole structure of sustenance is entirely different, as information technology and high-tech products have replaced agriculture as our main source of wealth.

We should therefore expect that, as economic and technical development change the conditions in general and increase freedom of choice in particular (Charles & Bradlesy, 2009; Pinker, 2008), changes in the proportion of women in any occupation might level off at any point below 50 percent, or surpass 50 and continue to 70 or 90 percent. In fact, this is what has happened with university graduates (63% women) and in several professions, such as newly graduated physicians (57%) veterinarians (90%), and chief executives in the public sector (65%; all figures from Statistics Sweden, 2014). Another series of authoritative statements is issued by the Swedish Department of Justice, in its 68-page *promemoria* with the most recent attempt to legislate quotas for boards of company directors:

> "The Cabinet wields a policy whose purpose is to combat stunting gender norms and structures. Women and men shall have equal possibilities to form their lives and reach positions of power and influence. That is not how it is today. The boards of leading Swedish companies have historically had a very low proportion of women. The explanation cannot be that women lack the qualifications to partake in such contexts. Women have because of their sex been cut out from the economic decision-making and one power-base in society. Important decisions regarding, for example, commercial and industrial life, employment, consumers, and the environment have therefore been made by men. An important goal for the Cabinet's sex-equality politics is to break the male predominance on the leading positions in Swedish commercial life. It is furthermore in the interest of the companies to take advantage of the competence that women have. … Several cabinets have left it to the companies themselves to manage the skewed sex distribution. It is however just that the Government intervenes with regulations, if the companies fail to exhibit sufficient results. … The Cabinet has, to push the development, set the minimum proportion of the underrepresented sex to at least 40 percent among the listed companies' board members in the spring of 2016." (Justitiedepartementet, 2016, September 9, pp. 13-14, my translation)

Here, the goal is frankly to render women more executive power, and to achieve this end the state claims it has the right to force private companies to have at least 40 percent women in boards and as CEOs. The quote also claims that women have the same qualifications as men, at the same time as women have unique competencies, which I assume should be understood as increasing the companies' profit. Finally, it states that women have intentionally been discriminated against, for the explicit purpose of isolating them from power in society. Similar points are also raised with regard to acedemic professors by the current minister for higher education in Sweden, Helene Hellmark Knutsson:

> "Although Sweden is world-leading when it comes to the proportion of women in the labor market, and although 60 percent of the students have long been women, three out of four professors are still men. … All too often have notions about the male genius trumped competence, and too often have internal recruitment and networks played a greater role than hard work. … If Sweden is to be an eminent science and research nation, a more equal university is required. Your network should not determine if you become professor or receive funding, but your competence and the quality of your research." (Hellmark Knutsson, 2017, my translation)

This quote further asserts that the sex ratio amongst university students should predict the ratio amongst professors, that selection in academe is biased by sex stereotypes, that academics engage in outright sex discrimination, and that academe is thereby robbed of the relatively higher competence of women. First and foremost, these claims ignore the available knowledge, as they make no allowance for universal, cross-cultural, and well-documented psychological differences with medium to large effect sizes. Nevertheless, the indetermination problem makes it perfectly viable to argue that some or perhaps all of these differences do not in fact affect the current sex ratios. But it also means that it is impossible to tell to what extent the increase in women's representation in higher education from almost nothing to over 60% may be attributed to these environmental changes alone, or perhaps to hormonal changes, through exposure to contraceptives and environmental emissions (e.g., Skakkebaeck et al., 2016). Its attribution to changes in attitudes or norms, however, raises again the specter of causality: Is it more likely that certain attitudes and norms cause economic growth and technical development, or that the conditions created by economic growth and technical development cause certain attitudes and norms? They seem impossible to disentangle.

The conclusion is that the main argument for quotas falls if, as I have argued, it is impossible to prove that forcing an increase in the proportion of a certain demographic category eventually leads to a self-sustaining proportion on a higher level, based on competence. The other main arguments for quotas are that any uneven proportion (1) robs the market of valuable competence and (2) is evidence of discrimination, because the sexes are equal. These points are contradictory and cannot both be true. If men and women have exactly the same competencies, then it doesn't matter if 100% are men or 100% are women, the level of success would be exactly the same. Only if you accept that there is a sex difference is there any point in attempting to tweak the sex ratio in order to increase competence.

Therefore, one must decide if there is any group difference or not. If there is not, then any form of quota or affirmative action is futile. Furthermore, quotas could logically make no difference to the competence, job success, or even the life satisfaction of the selectees. Even if one would argue that the differences lie only in interests or in selectees' perceptions about what is appropriate for them, such factors are non-trivial and affect job success and life quality (Meisenberg & Woodley, 2015). The idea that the state or any other authoritative body should attempt to thwart individuals' choices, interests, or preferences is patronizing and reflects a lack of faith in, and respect for, the autonomy and integrity of the individual.

If there is any psychological sex difference, however, then quotas that change the sex ratio will make a difference for the outcome. Whether that is of any benefit depends on the trait, the demands of the position, and the direction of the change, among other things. For example, you might observe that women cooperate more and that this leads to greater overall productivity, compared to men's greater focus on individual competition. Even though that greater competition might lead to, say, a larger number of innovations, perhaps as a result of putting in more late-night and weekend hours, you feel that they are of less value to your organization than is overall productivity. In addition, you may have data showing that in your organization the voluntary allocation of unpaid work hours will eventually entail a cost in terms of increased sick leave. In such a case, you would seem to improve things by hiring more women, for example by means of quotas.

No such deliberation can be observed in the debate on quotas, however. Striving for sex equality is largely motivated by liberating individuals from the shackles of tradition and stunting normativity. Nevertheless, the Swedish Establishment's corrective efforts are only directed at the most prestigious positions in society that are still male dominated, such as academic professors and large corporation board members and CEOs. It seems not to be troubled by the female dominance amongst physicians, psychologists, veterinarians, and managers in the public sector. Nor does it take corrective action against the draconic discrimination that must underlie the much greater exclusion of women from occupations such as car mechanics, garbage collectors, plumbers, and excavator operators. Unfathomably, it does not propose legislation that will save the misguided nursing aides from their overpowering drudgeries, and instead enrich men's stunted emotional life by lifting and cleaning patients. I fear that suspicious minds might construe this pattern as harboring a plain quest for power, rather than the liberation that is advertised.

Seriously, however, the popular idea that sex ratios in outcomes are related to misogyny and "patriarchal structures" is inconsistent with the lack of any simple association with status or income levels. For example, auto mechanics and electricians are relatively low-payed jobs, considering the level of competence, and the ominous wage gender gap almost vanishes when controlled for a range of rational causes, including years of experience, work hours, and so forth (Bugeja, Matolczy & Spiropoulos, 2012; Leslie, Flaherty & Dahm, 2017; Liu, 2016; O'Neill & O'Neill, 2006; Schirle, 2016).

What then if we accept that there are psychological sex differences? It is obviously roundabout to select desirable traits using sex as a criterion, when they are merely probabilistically associated with sex. In other words, quotas can only be partly effective to select the desired properties, because of the overlap between the sexes. Selecting by sex will include some women who are just as competitive as the average man in the organization, at the expense of excluding some men who are just as collaborative as you would like them to be. To be clear, quotas and the like also constitute explicit and institutionalized sexism.

The obvious conflict between selecting from the favored category and selecting the more able individual is sometimes veiled behind additional conditions. Such conditions may be to apply the quota only when qualifications are identical, insignificantly different, or sufficient to perform the task. For example, local regulations for the Borås Polytechnic state that a person of the underrepresented sex shall be hired over a person of the other sex, provided their qualifications are equivalent or essentially equivalent (Högskolan i Borås, 2010). Having two applicants with identical qualifications is extremely unlikely, and will even so be obscured by assessment error. Thus, systematically selecting the applicant from the target category with sufficient or insignificantly less qualifications constitutes selecting the less qualified nevertheless, provided that the favored group is in fact less competent on average, which was the reason for applying quotas in the first place.

Quotas do not work very well to counter possible discrimination either. Let us assume that meritocratic assessment is systematically biased against a certain group. First, how could bias even be determined, if one cannot trust the assessment of merit? For example, bias would be demonstrated if amongst those selected for a certain position, individuals from one group have less merits (i.e., qualifications) on average than those from another group. Or, in the case that high-merit individuals are not sufficient in numbers to fill all the available positions, bias would be demonstrated if the proportions selected from different groups were at variance with the distribution of high-merit individuals in the population. But if we argue that the assessment of merit is not valid, then it would also be logically impossible to assess if the current selection or proportion is biased or not. Second, how could the magnitude of this bias or its outcome be estimated, so that an equivalent counter-bias be applied? Without being able to assess both the bias and the effect of its countermeasures, the latter stands the risk of overcompensating or undercompensating. Third, how could the most able amongst the favored category be selected, given the premise that the meritocratic assessment is flawed? The same bias that is assumed to favor a certain identified group may well apply to properties of individuals within each group, leading to bias in selecting from within that group.

Selection by quotas may also entail undesirable social effects. Quotas are intrinsically unfair to the individual, who may have the desired level of a trait needed to do the job but is excluded because of her sex, or who may have an undesirable level of a trait but is included because of her sex. This entails a cost in terms of social tension and perceived unfairness which has to be balanced against the possible value of compensating for actual unfairness. Furthermore, all discrimination based on demographic categories or group differences is divisive, conflict-driving, and may create a disproportionate emphasis on these differences. Quotas have to be defended with some sort of group difference, whether this is attributed to psychological traits or other rational causes, or to discrimination and other externalities. But to focus on group differences in legislation, politics, and public debate creates and reinforces stereotypes.

Finally we can, for the sake of argument, play with other traits that may be difficult to assess in the individual but are known to differ between the sexes. Men's higher risk taking probably makes them more likely to commit white-collar crimes such as bribery, insider trading and embezzlement, which may be taken as an argument for companies to keep men out of leadership positions. Women tend to be higher in verbal fluency and memory, and should therefore be good at interpersonal skills. These skills are presumably important for leadership, while male strengths in spatial ability may be more important for abstract thinking and mechanical comprehension than for leading a company or ruling a country. It is clear that males compete more than females (Lindenfors & Tullberg, 2011), and the reason that males are more ambitious and competitive could be that in ancestral societies the relationship between dominance status and reproductive success was steeper in males than in females (Betzig, 2012). Competitiveness might be an asset when it leads to more creativity and effort, but might lead to destructive office politics and conflicts of interest in top management. It could therefore be argued that the power games played by male leaders cause collateral damage, if only because it is often the most combative rather than the most competent who makes it to the top.

Indeed, most organizations want team players rather than transformational leaders, which may be justified to the extent that transformational leaders cause more damage than the average bureaucrat. What is in demand is, by and large, not exceptional ability, but basic competence combined with social skills and acquiescence to the established hierarchy. This would be characteristic of mainly administrative organizations, such as public government. Exceptional abilities in terms of creativity, intelligence, persistence, and originality would seem to be more in demand in knowledge- and innovation-producing organizations, such as universities and high-tech companies (but see Dutton & Charlton, 2016). Women's lower aggressiveness, competitiveness and risk-taking, and their higher agreeableness and harm-avoidance, might make many of them quite happy to escape the pursuit of status and money. If so, pushing women into highly competitive occupations benefits only the minority of highly competitive women, while possibly harming the majority of women (cf. Madison et al., 2014; Meisenberg & Woodley, 2015)

Thus, one could make the point that quotas are justifiable and beneficial precisely because there are evolved sex differences in one or more of these traits. However, a more straightforward and effective way to obtain individuals with the desirable traits for each organization is to directly select for them, by adopting them as selection criteria. It has also been argued that the sheer proportion of the sexes in a social setting affects individuals' behavior (e.g., Nauts et al., 2012; Stoet & Geary, 2012), and that a mixed group is more pleasurable to work in. These are important questions that both proponents and opponents of quotas should state explicitly.

6. Conclusions

It is logically incoherent to impose selection based on group membership, such as quotas, unless one acknowledges that there is a group difference in some trait that affects the outcome in the domain in which the selection takes place. Only if such a group difference is acknowledged might a quota decrease the proportion of individuals who are more likely to have undesirable traits that are difficult to measure. It is more effective to directly select for desirable traits than for group membership, however, as traits are normally distributed and overlap across groups. It would, accordingly, entail the greatest benefits to improve meritocratic assessment and to apply it more extensively and systematically. The better the assessment of merit, the less scope for bias or discrimination. Accurate and reliable assessment of merit is also a requirement for assessing the magnitude of bias and to devise proportional countermeasures.

Also, quotas inevitably entail negative consequences that should be weighed in. From the perspective of the individual, it is fairer to be selected on the basis of traits one actually has, rather than a stereotype of the group one belongs to. From the perspective of society as a whole, focusing on group differences and selecting based on group membership is divisive and conflict-driving, and stirs hostility based on competition over resources and social status. These arguments and conclusions are applicable to other demographic categories and group differences in general.

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Sex Differences in Cognitively Demanding Games: Poker, Backgammon and Mahjong

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Richard Lynn argues with his developmental theory of sex differences in intelligence that men's 4 point higher IQ than that of women combined with men's greater IQ variance and greater male competitiveness are sufficient to explain the greater numbers of men than of women in top positions. He argues further that it is unnecessary to postulate the construct of an invisible glass ceiling that prevents women from rising to the top in educational and professional attainment.

This position can be tested by examining sex differences in the card and board games of Poker, Backgammon and Mahjong. These are highly cognitively demanding games that require high performance across domains – involving, for instance, visuospatial ability, short term and working memory, processing speed, and planning (e.g. Billings et al., 2002; Sato et al., 2017). As such, it can be predicted from Lynn's thesis that there would be more men than women among top players. Some results for the numbers of men and women winners in national and international competitions open to male and female participants in these games are summarized in Table 1. The results show that in fact there have been many more men than women as winners in these cognitively demanding games and therefore support Lynn's thesis.

Importantly however, the total of the four results is 123 men and 8 women, giving a ♂/♀ ratio of 15.4:1. This is much greater than the men to women ratio of 5:1 at an IQ of 145 and with a greater male standard deviation calculated by Nyborg (2015, p. 51).The present data therefore support Lynn's conclusion that there must be some other male advantage responsible for their much greater numbers among the winners of these cognitively demanding games, and that greater male competitiveness is the likely factor.

Furthermore, while it must be noted that it is possible that men are exposed to or socially encouraged to play these cognitively-challenging games more than women, there is nothing to actually prevent women from playing these games or entering any of the competitions and no glass ceiling to socially prevent them from doing as well in them as men and reaching higher ranks. Therefore the much greater number of men than of women among the top players is further evidence that the existence of an invisible glass ceiling that prevents women from rising to educational and professional eminence does not appear to stand up to critical examination, especially considering the rising social encouragement for women to pursue professional careers since the first feminist waves.

Table 1. *Numbers of men and women winners at Poker, Mahjong and Backgammon.*

Country	Game	Years	Men	Women	Reference
World	Poker	1970-2016	47	0	World Series of Poker, 2017
USA	Poker	1996-2010	14	0	Theta Poker, 2016
World	Backgammon	1967-2016	45	5	Cole, 2017; Kerr, 2007
World, Europe	Mahjong	2002-2016	17	3	European Richi Championship, 2016; Open European Mahjong Championship, 2016; Shimmer Shi, 2015; World Mahjong Championship, 2017; World Series of Mahjong, 2017.

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Sex Differences in the Performance of Professional Go Players

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Lynn presents a review of the evidence for his developmental theory of sex differences in intelligence, which claims that adult men have a higher average IQ than women. Fernandes (this issue) has extended Lynn's thesis by examining the implication that there should be more men than women among the top players of cognitively demanding games and has shown that this is so for Poker, Backgammon and Mahjong. In this paper, I report sex differences for the cognitively demanding and complex game of Go that is played in the East Asian countries of China, Japan, Korea and Taiwan.

A Chinese fan website called Hong Tong Go [http:// www. hoetom. com/ index.html] contains information on Go players. It provides basic information (name, gender, grade, nationality, whether they are professional players, and birth date) about the players. Details of the players were downloaded in January 2017. In China, those with a professional dan rank are considered professional players (Tianyaqiren, 2011). To become a professional player and to get a professional dan rank in the first place, one has to take part in the National Go Grading Competition (Xie, 2013). Only players under a certain age (16 before 2010, 25 since 2010) were allowed to take part in the competition. It takes more than 10 years of hard and expensive training to gain a grade (Zhu, 2013). After having gained professional status, players can upgrade their rank through rank upgrading events and international Go events. The proportions of males by nationality are shown in Table 1. As we can see, males are more likely to become professional Go players in all of the surveyed countries.

Table 1. *Proportions of males among professional Go players by nationality.*

Gender		China	Japan	Korea	Taiwan	Other	Total
Female	N	106	78	48	8	9	249
	%	18.89	9.90	12.28	9.64	16.36	13.26
Male	N	455	710	343	75	46	1,629
	%	81.11	90.10	87.72	90.36	83.64	86.74
Total		561	788	391	83	55	1,878

However, it is not possible to compare ability for the two sexes from the proportions in China because men and women compete separately in the National Go Grading Competition. The number of women admitted increased from 3 to 5 in 2012 while the number of men remained at 20 (Xie, 2013). In rank upgrading events, players from both sexes compete together in a fair way in China (Luo, 2007). To see the difference in ability, let us look at the relationship between the proportions of male players and achievement in the game. The proportions of males by dan rank are shown in Table 2. As we can see, male professional players are more likely to achieve a higher dan rank. The median dan rank is higher for males than for females (Wilcoxon rank-sum test $p= 0.0000$). It suggests a male advantage among professional Go players.

Table 2. *Proportions of males by dan rank among Chinese (excluding Taiwan) professional Go players.*

Gender		1	2	4	5	6	7	8	9	Total
Female	N	22	42	9	11	6	1	3	4	98
	%	44.90	26.09	12.68	15.07	8.96	2.78	21.43	6.56	18.42
Male	N	27	119	62	62	61	35	11	57	434
	%	55.10	73.91	87.32	84.93	91.04	97.22	78.57	93.44	81.58
Total		49	161	71	73	67	36	14	61	532

The data show that males are not only more likely to become professional Go players, they also perform better in events after they have become one. It demonstrates that a gender gap in performance in favor of men exists in Go just as in Poker, Backgammon and Mahjong. While the results are compatible with Lynn's theory, they do not by themselves allow a firm conclusion whether the greater male performance in Go is the result of greater cognitive ability, greater ambition, or other sexually dimorphic cognitive or personality traits.

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Sex Differences in Intelligence: Reply to Comments

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Invitations to comment on the target paper IQ were sent to all those who were cited as asserting that there is no sex difference in intelligence, but few chose to do so. I thank all those who accepted the invitation and reply to their comments below.

David Becker and Heiner Rindermann have added results from studies in Germany and Brazil supporting my theory on cognitive sex differences and their development. They also show that there are associations between hormonal transitions during adolescence, especially in women, and increasing sex differences in cognitive abilities, particularly spatial ability, during adolescence. They suggest that these maturation-related changes are best explained from an evolutionary perspective, as cognitive and ecological specializations of the sexes, with the additional benefit of increasing group fitness due to differentiation of social gender roles. In addition, they argue that historical and cultural changes have first reduced male-favoring gender gaps in education and in many cases reversed them. Together with changes in the job market, this has affected sex differences in STEM-related abilities and modifies formerly stable sex differences.

Roberto Colom makes four principal points. First, he agrees that men obtain higher average scores on "intelligence in general" defined as the IQ obtained on the Wechsler and numerous other tests. Second, he argues that there is no sex difference in *g* as shown in his own study. Note, however, that he used the method of correlated vectors to assess sex differences in *g,* that there is considerable disagreement about whether this is an appropriate method for measuring *g,* and that Wicherts (2017, p. 35) provides an extensive critique of the method concluding that it is "deeply flawed". Further, most studies have shown that there is a male advantage in *g*, as noted in the target article. I think this should be regarded as an open question until consensus on the correct method for measuring *g* been reached.

Third, he argues that the solution to the brain size-intelligence paradox is that the greater average brain size of men is devoted to the computationally demanding task of visuo-spatial processing, on which men excel, and that the male advantage on the Progressive Matrices may be attributable to its visuo-spatial component. He is right that the Standard Progressive Matrices has a visuo-spatial component as shown by Lynn, Allik and Irwing (2004), but this is not the case for the Advanced Progressive Matrices which Waschl et al. (2016) have shown is unidimensional with no visuo-spatial component and yet males score higher on this. Furthermore, males obtained higher scores on abstract reasoning in the DAT, given in Table 1 of the target article, on which 18 year old males scored 2.4 IQ points higher in the US, 3.7 points higher in the UK, and 5.4 points higher in Spain, giving an average of 3.8 IQ points and very close to my estimated male advantage of 4 IQ points among adults. In addition, males also have large advantages on general knowledge and working memory.

Fourth, he summarizes his own neuroimaging studies confirming that men have larger brains but showing that this extra volume is associated with better scores on a highly demanding spatial test, not with *g,* and also supporting his greater female neural efficiency hypothesis stating that women have greater neural efficiency in requiring less neural material for achieving the same cognitive ability as men. These are important contributions to the debate on this issue and raise the interesting question of why women should have evolved greater neural efficiency than men. Note, however, that in his paper presenting the greater female neural efficiency hypothesis he writes that “the evidence regarding sex is largely confusing. Haier and Benbow (1995) failed to find positive evidence for the neural efficiency hypothesis” (Colom et al. 2013).

Edward Dutton has summarized the relevance to sex differences in achievement of Baron-Cohen’s concept of the ‘male brain’ with its higher “systemizing ability” consisting of the analysis of the variables in a system, working out its rules, and creating systems to make sense of novel situations, and the ‘female brain’ with its greater “empathizing ability” consisting of the identification of other people’s emotions and thoughts and working out the best way to respond to them so that they feel happy. He finds that the extreme male brain is high functioning autism and that this (when combined with the high IQ that is also more common in men) is associated with genius. The ‘male brain’ is partly determined by a high level of testosterone. It is independent of intelligence and thus makes an independent contribution to the greater numbers of men among high achievers.

Heitor Fernandes considers the implication of the developmental theory that there should be more men among high achievers by examining the numbers of men and women among top players in the cognitively demanding games of Poker, Backgammon and Mahjong. He shows that men greatly outnumber women among the top players of the three games. His contribution provides further evidence that men have a higher average IQ than that of women, a greater standard deviation and/or are more competitive.

Mingrui Wang extends Fernandes' comment showing that there are more men than women among the top players in the cognitively demanding games of Poker, Backgammon and Mahjong by showing that this is also the case with the cognitively demanding and complex game of Go that is played in East Asian countries. He reports that men are 86.74 percent of top professional Go players and women are 13.26 per cent in China, Japan, Korea and Taiwan, and that in China men are 93.44 percent of the top dan rank 9 professional Go players and women are 6.56 per cent. His contribution provides further evidence that men have a higher average IQ than that of women, a greater standard deviation and are more competitive.

These contributions reporting that there are more men than women among the top players in cognitively demanding games were made with regard to Chess by Howard (2014), who noted that it has been shown that ability in Chess requires a high IQ citing Frydman and Lynn (1992) and confirmed by Burgoyne et al. (2016). Howard reported that in 2012 there were 1324 men and 26 women Chess grandmasters and over the years 1975 to 2014 there was a male advantage of about one standard deviation in the performance of the top 10 and top 50 of all international players. He concluded that higher male ability is the most plausible explanation for the greater number of men among top Chess players: “Males score higher on average in visuospatial abilities and many more males score at the upper IQ extreme” and that the male predominance in Chess is “probably partly innate” (p. 219-20). He was right that the much greater number of men with high IQs is part of the explanation for their much greater number of among top Chess players.

However, his suggestion that higher male visuospatial ability contributes to the male predominance among top Chess players is not supported by the meta-analysis of the relation between intelligence and ability in Chess that concluded that ability in Chess is positively correlated with fluid intelligence at .24, with numerical ability at .35, with verbal ability at .19, and with visuospatial ability at .13 (Burgoyne et al., 2016). This study showing only a very low correlation of .13 between ability in Chess and visuospatial ability suggests that the male predominance in top level Chess is more attributable to their greater fluid intelligence ($r = .24$) and numerical ability ($r = .35$). Howard's conclusion that there are many more men than women in top level Chess has been confirmed in 24 countries by Blanch (2016), who shows that this cannot be explained by the higher participation rates of men.

Two other cognitively demanding games are Bridge and Scrabble. Success in Bridge requires the integration of information from a number of sources to reach the best decisions. This information includes the value of the cards held by the player, the likely values of the cards held by the player's partner and by each of the two opponents that can be inferred from the bidding. The good player evaluates this information to make the best decisions from a number of alternatives during the bidding and the play. As Charness (1979) writes in his analysis of the cognitive demands of Bridge, “the skilful bridge player frequently uses the bidding and sequence of plays to infer the distribution and identity of cards in the unseen hands.” In addition, a good working memory is required to do well because during the play information that has been inferred from the bidding and from the cards already played has to be put into storage while attention is given to ongoing problems, and then retrieved from storage when needed. It has been shown by Kyllonen and Christal (1990) and by Colom, Chuderski and Santarnecchi (2016) that working memory is an important component of intelligence. The best Bridge players in the world are the 84 living Open World Grand Masters. Only one of these is a woman.

Scrabble is another cognitively demanding game involving combining letters to make words. It has been shown by Toma, Halpern and Berger (2014) that top scrabble experts have “extraordinarily high levels of visuospatial and verbal working memory capacities” and score 1.23*d* higher than elite college students who scored at the 93rd percentile of the quantitative SAT. There have been 38 winners of the American National Scrabble Championships 1978-2016 and 16 winners and runners-up of the Canadian National Scrabble Championships 1996-2013. All of these have been men.

These studies showing that there are much greater numbers of men than of women among the top players of these cognitively demanding games calls into question the “glass ceiling” that has frequently been proposed as the reason that women are under-represented in senior positions in corporations and the professions. It is a notorious fact that there are many more men than women at the top of all professions and among the very rich. Wai (2014) has reported that there is a male-female ratio of 9.4:1 among the world's billionaires. Nyborg (2015, p. 51) gives data for a number of countries showing that about 20 percent of senior positions in academia and business are women. More recently, the European Commission reported that in 2016 there was an average of 23 percent of women on the boards of large companies in the 27 nations of the European Union, ranging from 5 percent in Malta to 37 percent in France. The reason for the high percentage in France is a legal requirement for 40 percent of female directors by 2017. In Britain, only 20 percent of university vice-chancellors in 2015 were women (Nath, 2017), and in the Netherlands only 18 percent of university full professors in 2016 were women (THE, 2017). In the United States, among those with an advanced degree women earn 74% as much as men (American Association of University Women, 2016).

The concept of the glass ceiling to explain the under-representation of women in senior positions in corporations and the professions was popularized by Gay Bryant (1984), who wrote that there are many women middle managers but "a lot of women are hitting a "glass ceiling" and finding they can rise no further." In 1991 the United States Congress was so concerned about this disparity that it created the Federal Glass Ceiling Commission to investigate the problem and defined the glass ceiling as "the unseen, yet unbreakable barrier that keeps minorities and women from rising to the upper rungs of the corporate ladder". In 2016 the Dutch Network of Women Professors asserted that the small number (18 percent) of women among university professors in the Netherlands showed that "There is a ruthlessly thick glass ceiling between job levels" (THE, 2017). Janet Hyde (2007, p.142) has written that "Women in science report significant discrimination." Rainbow Murray (2016, p. 6), a professor of politics at Queen Mary University of London, has written that "Men often form networks with other men and recruit in their own image while overlooking women." Oyvind Martinsen (2017, p. 30) of the BI Norwegian Business School has written of "the glass ceiling that has long existed within universities and business schools".

While the glass ceiling might explain the under-representation of women in corporations and in medicine, the law, the universities and in other institutions that are largely run by men, it is doubtful whether it can explain the smaller numbers of successful women in fields where men are not able to discriminate against women. These include awards for outstanding intellectual achievement. Table 1 shows sex differences for the Nobel Prize, the highest award for intellectual achievement in physics, chemistry, physiology and medicine, and literature, and for the Wolf, Fields and Abel awards for mathematics. This gives the numbers of men and women who have received these awards up to 2016. The right hand column gives the percentages of the prize winners who were women.

There are four points of interest in the results. First, in discussing the much greater numbers of men that have won the Nobel Prize, Jausovec and Pahor (2017, p. 81) write: "Can all of these be attributed to sociocultural influences and the glass ceiling effect? Probably not. The first female prize for physics was awarded to Marie Curie Sklodowska in 1903 and the second to Maria Goeppert Mayer in 1963. One can speculate that in 1903 and even in 1963 there was much more gender inequality and male chauvinism than at the present time." This is a good point. No women have won the Nobel Prize for physics in the last 53 years showing that greater gender equality has not increased the small numbers of women prize winners. Second, women have had greater success in literature than in the sciences. This would be expected because women's verbal abilities are about the same as those of men but they have still only won 12.84 percent of the prizes. There is no glass ceiling to prevent women writing good novels for which nearly all the literature prizes are given. This shows that there must be other factors in addition to the IQ and the glass ceiling responsible for the small number of women getting the literature prize. Third, there are many more men than women recipients of the three awards for mathematics. There is no glass ceiling to prevent women from obtaining these awards. Fourth, the number of men prize winners is greater than would be predicted from their 4 point higher IQ showing that there must be other factors contributing to the preponderance of men.

Table 1. *Men and women awards for Nobel Prizes and mathematics prizes.*

Prize	Subject	Men	Women	% Women
Nobel	Physics	203	2	0.98
Nobel	Chemistry	171	4	2.28
Nobel	Physiology	199	12	5.69
Nobel	Literature	95	14	12.84
Wolf	Mathematics	57	0	0
Fields	Mathematics	61	1	1.61
Mathematics	Mathematics	16	0	0

Furthermore, there is no glass ceiling to prevent women doing as well as men in Chess, Poker, Backgammon, Mahjong, Bridge and Scrabble. The much greater numbers of men than of women among the top players of these cognitively demanding games is further evidence that the existence of an invisible glass ceiling preventing women from rising to the top does not stand up to critical examination. The concept of the invisible glass ceiling calls for William of Ockham's (1281-1347) razor: "Hypothetical entities should not be unnecessarily multiplied."

Jim Flynn has made two principal points. First, he argues that there is no sex difference in IQ in the current generation of women in developed nations and where samples appear to be large and representative. He contends that women have a fluid intelligence of 100.5 assessed from Raven's data for general population samples for modern nations. To assess this contention, the results of sex differences (*ds*) for the Standard and Advanced Progressive Matrices in general population samples for ten modern nations published since the Lynn and Irwing (2004) meta-analysis are given in Table 2 and show that it is only in the sample from Argentina that women scored higher than men. The mean male advantage of the ten studies is .206*d*, equivalent to 3.1 IQ points.

Table 2. *Studies of sex differences (ds) for the Standard and Advanced Progressive Matrices in general population samples aged 20-89 years. Minus signs denote higher means obtained by females.*

Location	N ♂	N ♀	*d*	Reference
Scotland	210	217	0.11	Deary et al., 2004
Scotland	230	313	0.29	Deary et al., 2004
Brazil**	104	265	0.48	Rosseti et al., 2009
New Zealand	143	187	0.22	Fletcher & Hattie, 2011
Argentina	374	390	-0.02	Flynn, 2012
Brazil**	454	534	0.10	Flores-Mendoza et al., 2013
Serbia	62	74	0.27	Čvorović & Lynn, 2014
Romania*	618	823	0.18	Iliescu et al., 2016
Australia**	128	327	0.30	Waschi et al., 2016
USA***	393	503	0.21	van der Linden et al., 2017

* Progressive Matrices Plus; **Advanced Progressive Matrices; ***Penn PM, a short version of the Progressive Matrices.

Second, Flynn argues that differences in achievement between men and women have more to do with character than with intellect. Women tend to be less violent and combative than men and are more sensitive to other human beings. This difference is widely accepted and has been elaborated in the comment by Dutton showing that women have higher empathy that has recently been confirmed by Pietschnig and Gittler (2017). I agree that this difference is important and contributes to the over-representation of men in top jobs.

Adrian Furnham makes important points on some of the personality differences that contribute to the greater success of males than of females in many areas of life. These are that males are more self-confident shown in his numerous studies of their higher self-estimated intelligence. Males are more competitive and are greater risk-takers. I agree with his conclusion that “if males are more desirous to succeed (achievement orientation), willing to put in the effort, and risk a great deal in the process, it is not surprising that they have a greater success rate in many fields.”

Gerhard Meisenberg has confirmed my developmental theory by examining the data of the Armed Services Vocational Aptitude Battery in the NLSY79. He shows that the score increases between age 15 and age 23 were greater in males than in females, supporting an essential element of the theory. He shows also that neither the sex differences themselves nor their developmental changes are related in any consistent way to the *g* loadings of the subtests and therefore that sex differences should not be conceptualized as differences in *g*.

Helmuth Nyborg provides further evidence for sex differences in intelligence among 12-17 year olds measured as *g*-factor scores derived from the ASVAB subtests. He shows in whites, Hispanics and blacks males obtain higher IQs than females at age 17. In his white sample shown in his Figure 2 pre-pubertal boys hold a slight lead in intelligence development and this becomes statistically significant around age 15. The likely explanation for the earlier appearance of this higher male *g* is the presence of tests of mechanical comprehension and electronics information in the ASVAB, as he points out. His data are generally supportive of the developmental theory.

His Figure 3 confirms previous studies that the IQ distribution is wider in males than in females in 17-year-old whites from the NLSY97 data. He estimates there should be about 20% females at an IQ of 145 leading to an expectation that this would be about the proportion of women heading large companies and that this is approximately the case in Denmark. This proportion of women has been shown in a number of other countries. For instance, the European Commission reported that in 2016 there was an average of 23 percent of women on the boards of large companies in the 27 nations of the European Union. In Britain, 20 percent of university vice-chancellors in 2015 were women (Nath, 2017) and in the Netherlands 18 percent of university full professors in 2016 were women (THE, 2017).

Davide Piffer discusses the contribution of the greater male variability of IQ to the greater number of men among high achievers and the explanation of this. He suggests this may be attributable to X-linked transmission of intelligence and/or to higher testosterone that could increase the expression of genes related to neurological development or cognition.

Invitations to comment on the target paper were sent to a number of women academics who are concerned about gender inequality. One of these was Clare Hemmings who has been Professor and Director of The Gender Institute at the London School of Economics since 1998. The Gender Institute was established in 1993 to teach courses and carry out research on issues associated with gender and gender inequality. In addition to the director, it has a staff of twelve including Professors Mary Evans, Diane Perrons, Wendy Single and Nail Kabeer. Clare

Hemmings did not reply to the invitation.

An invitation to comment was also sent to Emma Rees who is professor and director of the Institute of Gender Studies at the University of Chester. Her book *The Vagina: A Literary and Cultural History* has been widely acclaimed by feminists for its account of men's oppression of women. Lisa Downing, professor of French Discourses of Sexuality at the University of Birmingham, has written “At last! A book on the vagina that I feel privileged to endorse. This careful cultural and literary history explores the vagina primarily as a loaded cultural symbol. It critiques the numerous ways in which the female sexual organs have had deleterious meanings projected onto them by a patriarchal society. A magnificent achievement!” Another admirer is Sally Hunt, professor of Cultural and Gender Studies at the University of Sussex, who has written “this really wonderful book on the history of the vagina... The Vagina bedazzles”. Emma Rees did not reply to the invitation to comment on the target paper.

Another to whom an invitation to comment was sent was Uta Frith, professor emerita of cognitive development at University College, London, and a Fellow of the Royal Society and of the British Academy. She is chair of the Royal Society diversity committee that was established in 2014 to examine why women were under-represented in receiving funding. In 2014, 10 women out of 116 applicants and 35 men out of 350 applicants received Royal Society University Research Fellowships. Frith is reported as saying that her committees regarded this disparity as “a wake-up call” and “there was a general feeling that something needed to be done... not just in this country but world-wide” (Else, 2016, p. 7). She did not reply to the invitation to comment on the target paper.

Others who did not reply to the invitation to comment on the target paper include Gina Rippon and Helen Haste. Gina Rippon is professor of cognitive neuroscience at Aston University and has written that gender differences are “extremely small and the distribution of measured variables almost always overlapping” and that “gender inequality remains a matter of global concern (Rippon, 2016, pp. 921-2). Helen Haste is emerita professor of psychology at the University of Bath and a visiting professor at the Harvard School of Education. She discusses gender issues in her book *The Gender Metaphor*, in which she writes that “gender oppression is pervasive”.

The only one who replied to the invitation to comment was Baroness Susan Greenfield who graduated in psychology at the University of Oxford and is now the Oxford Professor of Pharmacology. She has expressed concern about gender inequality stating that “It does worry me that only 10% of science professors are women” (*The Times,* 2010, 15 April, p. 50). She expressed thanks for the invitation but regretted that she was too busy to send a comment.

Thus, the only reservations about the theme of the target paper came from Colom and Flynn. Colom contended that there is no sex difference in *g* but agreed that men have a higher average IQ defined as the aggregate of cognitive abilities measured by tests like the Wechsler. This leaves Jim Flynn as the sole defender of what has surely become a lost cause. As Helmuth Nyborg concludes: "[I]t is no longer scientifically acceptable to continue to tell readers of general textbooks and specialized publications that there is NULL sex difference in general intelligence. To the contrary, there is a reproducible adult sex difference, and it has been demonstrated to have practical value."

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