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Null Sex Differences in General Intelligence: Evidence from the WAIS-III

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There is an increasing number of studies claiming that the sex differences in general intelligence are “real.” The empirical evidence is based on the summation of the standardized sex differences in several cognitive batteries. However, the scientific construct of general ability rests on the correlations among test scores, rather than on their summation. The latter (ability in general) is an arbitrary variable, not a scientific construct. General ability is not a function of any particular cognitive test, but a source of variance evidenced by the correlation between several diverse tests, each of which reflects general ability (*g*) to some extent, but also group factors and test specificity. Because there are important educational, economic, and social consequences of a group difference in general ability, it is especially germane to evaluate the possibility of an average sex difference in its proxy measures, such as IQ. The Spanish standardization of the WAIS-III is analyzed in the present study. The sample was made up of 703 females and 666 males, aged 15-94, drawn as a representative sample of the population in terms of educational level and geographical location. Although a male advantage of 3.6 IQ points is observed, the difference is in “ability in general,” not in “general ability” (*g*). Given that the main ingredient of the strong association between IQ and a broad range of social correlates is *g*, and given that there is no sex difference in *g*, then the average IQ sex-difference favoring males must be attributed to specific group factors and test specificity.
Key words: general intelligence, sex differences, cognitive abilities, psychological assessment, practical validity

Un número creciente de estudios sostiene que “existen” diferencias entre los sexos en inteligencia general. Las pruebas empíricas se basan en la suma de las diferencias estandarizadas entre los sexos en diversas baterías cognitivas. Sin embargo, el constructo científico de inteligencia general se basa en la correlación entre las puntuaciones obtenidas en los tests, no en su suma. La suma de puntuaciones (inteligencia en general) constituye una variable arbitraria, no un constructo científico. La inteligencia general no es función de un determinado test, sino que constituye una fuente de varianza puesta de manifiesto por la correlación entre diversos tests, cada uno de los cuales refleja inteligencia general (*g*), factores de grupo y especificidad del propio test. Puesto que existen importantes consecuencias educativas, económicas y sociales de las diferencias de grupo en inteligencia general, resulta especialmente pertinente valorar la posibilidad de que exista una diferencia promedio entre sexos en medidas como el CI. En este estudio se emplea la adaptación española del WAIS-III. La muestra está formada por 703 mujeres y 666 varones de entre 15 y 94 años de edad, representativa de la población en nivel educativo y localización geográfica. Aunque se observa una ventaja promedio de los varones de 3.6 puntos de CI, la diferencia se debe a la “inteligencia en general”, no a la “inteligencia general” (*g*). Dado que el principal ingrediente de la fuerte asociación que existe entre el CI y un amplio conjunto de correlatos sociales es *g*, y que no existe una diferencia según el sexo en *g*, entonces la diferencia promedio de CI que favorece a los varones debe atribuirse a los factores de grupo y a la especificidad de los tests.
Palabras clave: inteligencia general, diferencias de sexo, aptitudes cognitivas, evaluación psicológica, validez práctica

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It is usually stated that sex differences in general intellectual ability are nonexistent (Brody, 1992; Colom, 1998; Halpern, 1992; Juan-Espinosa, 1997; Neisser et al., 1996). However, Ankey (1992, 1995), Rushton (1992), and Lynn (1994, 1998, 1999) noted a paradox: Males, on the average, have larger brains than females and brain size is positively associated with intelligence (Jensen, 1998; Mackintosh, 1998; Rushton & Ankey, 1996). Hence, it would be expected that males would have a higher average level of intelligence than females.

In an extensive review, Lynn (1994) calculated a mean sex difference in general intelligence of 3.8 IQ points favoring males, precisely the advantage that can be predicted from males' larger brains. This prediction is based on a mean correlation of .35 between in vivo brain size (measured by fMRI, see Rushton & Ankey, 1996) and IQ, and a sex difference of .78 SD in adult brain size (autopsied brains), hence a predicted male-female difference in IQ of $.35 \times .78$ SD = $.27$ SD $\times 15 \cong 4$ IQ points. Five years later, Lynn (1999, p. 10) stated that "males do have higher mean IQs than females by approximately 4 IQ points, commensurate with their larger average brain size. This conclusion holds, whether general intelligence is defined as the sum of the verbal comprehension, reasoning, and spatial group factors, as fluid intelligence or reasoning ability, or as Spearman's *g* measured from the first principal component or as the global IQ obtained from standard intelligence and aptitude tests, so long as this fulfills the conditions stipulated by Jensen." Lynn (1999) considered 20 further data sets on sex differences that correspond with the 1994 estimates for general intelligence (Lynn, 1994).

The question of whether or not there is a sex difference in general intelligence is especially germane for psychological assessment. Thus, for instance, the practical validity of measures of general intelligence is usually indicated by a significant predictive useful correlation with some educational, economic, or social criterion. Highly *g*-loaded test scores (IQ, see below) show a greater universal practical validity than any other psychological construct. IQ predicts performance in every kind of behavior that calls for learning, decision, and judgment. The validity of IQ is an increasing monotonic function of the level of cognitive complexity in the criterion. The statistical removal of *g* from any psychometric test or battery, leaving only group factors, produces a negligible practical validity when they are used in a representative population (Gordon, 1997; Gottfredson, 1986,1997a, 1997b).

The general factor (*g*) than can be extracted from a correlation matrix between several cognitive tests predicts scholastic achievement, because *g* is intrinsic to learning novel material, grasping concepts, meanings, and so forth. Furthermore, *g* is the main cognitive correlate and best single predictor of success in job training and job performance. Meta-analyses of hundreds of test validation studies have shown that the validity of a highly *g*-loaded test with proven validity for a particular job in a particular organizational setting is generalizable to all other jobs and settings (Ree & Earles, 1991; Schmidt, Hunter, Outerbridge, & Goff, 1988).

The *g* factor is still reflected in other broad social outcomes, as social problems such as dropping out of school, chronic welfare status, child-neglect, poverty, accident proneness, delinquency, or crime. These relationships are real independently of social class of origin. These social correlates have an inverse monotonic relation to IQ in the population, showing, on average, five times the percentage of occurrence in the lowest quartile of the total distribution of IQ as in the highest quartile (Herrnstein & Murray, 1994; Hunt, 1995; Mackintosh, 1998; Neisser et al., 1996).

The educational, economic, and social consequences of a group difference in IQ arise from two effects: (a) the statistical characteristics of the normal curve, and (b) the minimum probable threshold of the level of ability required for certain social attainments.

When two normal distributions of IQ have different means, although the curves largely overlap one another, a given cutoff-point on the IQ scale can make a very large difference between the proportions of the lower scoring group and the higher scoring group that fall below the cutoff-point. The further the distance of the cutoff-point from the mean of the higher scoring group, the larger will be the group difference between the proportion of each group that falls above or below the cutoff score (Jensen, 1980). Cutting scores on the IQ scale that fall at critical thresholds result in disparities between the proportions of the higher and lower scoring groups that fall into different social and occupational categories (Hunter, 1983, 1986; Hunter & Hunter, 1984; Hunter & Schmidt, 1990; McHenry, Hough, Toquam, Hanson, & Ashworth, 1990).

Consider a mean group difference of 3.8 IQ points. Assume that admission to a highly selective training course is based on a cutting IQ score of 120. What percentage of each group falls above the cutoff score? (See Figure 1.) For the group with a mean IQ of 100, the corresponding *z* score is 1.33. The area of the normal curve falling above 1.33*z* is 9.18 %. For the group with a mean IQ of 96.2, an IQ of 120 is equivalent to a *z* score of 1.59. The area of the normal curve falling above 1.59*z* is 5.59%. Therefore, an excess of approximately 3% of the higher scoring group falls above the cutoff score.

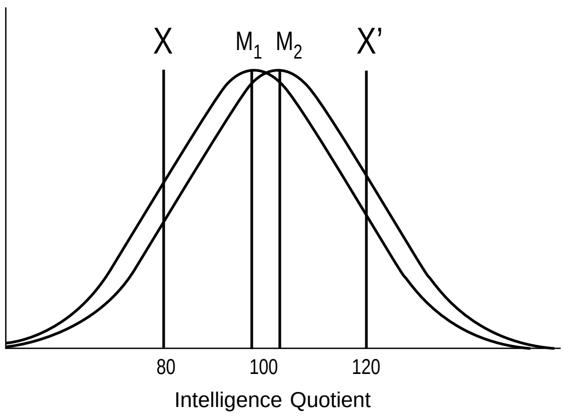

Figure 1. Two normal distributions: M_2 = 100 and M_1 = 96. The figure also represents two cutoff scores at X (IQ = 80) and X' (IQ = 120).

It should be noted that studies of sex differences in general ability have been confounded by improper definitions and measurements of general ability based on the simple *summation* of subtest scores from several batteries that differ in their group factors (for example, see reports by Lynn: Hattori & Lynn, 1997; Lynn, 1994, 1998, 1999). The analyses yield a mean sex difference in the total score, but such results are arbitrary, of limited generality, and of little scientific (and practical) interest (Jensen, 1998). Some recent analyses have pointed out a negligible sex difference in general intelligence defined as *g* after a broad variety of cognitive and scholastic batteries (Aluja, Colom, Abad, & Juan-Espinosa, 2000; Colom, Juan-Espinosa, Abad, & García, 2000; Jensen, 1998). Although the mean standardized sex difference was in strong agreement with the one reported by Lynn (1994, 1998, 1999; Hattori & Lynn, 1997), the difference was not attributable to *g*. It must be emphasized that the simple sum of various subtest scores is of no scientific or practical interest, because it cannot be considered a proper measure of general ability. The concept of general ability, defined as *g*, rests on the correlations among test scores rather than on their summation. The latter (ability in general) is an arbitrary variable, not a scientific construct.

The empirical fact that all mental abilities are positively correlated calls for an analytic taxonomy of mental abilities based on some form of correlation analysis. The dimensions found in the factor analysis of the correlations among a variety of mental ability measurements can be arranged hierarchically according to their generality (Carroll, 1993, 1997). The *g* factor is the most general of all and is common to all mental abilities. The *g* factor is a common source of individual differences *in all cognitive tests*. The knowledge and skills tapped by test performance merely provide a vehicle for the measurement of *g* (Jensen, 1992). Not every vehicle is a fine measure of the construct. The construct must be elicited in many different ways. It is not a function of any particular vehicle, but a source of variance evidenced by the correlation between several diverse tests, each of which reflects *g* to some extent, but may also reflect group factors and test specificity.

No pure test of *g* exists. The solution is to obtain a composite score from several highly diverse *g*-loaded tests. The greater the numbers of tests that enter into the composite score, the more the unwanted sources of variance are averaged out. In the best-standardized test batteries, 75 % or more of the variance of the composite scores consists of *g*. This is typical for most individual IQ tests (such as the Wechsler). Each test score reflects the level of *g* and the properties of the test itself (Cattell, 1978; Jensen, 1998).

In short, a key question in the research on cognitive sex differences is whether, on average, females and males differ in *g*. This question is technically the most difficult to answer and has been the least investigated. This article examines sex differences in terms of the *g* factor extracted from the Spanish standardization of the WAIS-III. We investigated whether there is any sex difference in general intelligence defined as *g*.

Method

Participants and Measures

The Wechsler Adult Intelligence Scale (WAIS-III; Wechsler, 1997) was standardized in Spain in 1998. The standardization sample consisted of 703 females and 666 men, aged 15-94 ($N_{16\text{-}19\ years}$ = 163; $N_{20\text{-}24\ years}$ = 153; $N_{25\text{-}34\ years}$ = 272; $N_{35\text{-}54\ years}$ = 408; $N_{55\text{-}69\ years}$ = 237; $N_{70\ or\ more\ years}$ = 136), drawn as a representative sample of the population in forms of educational level (academic level zero = 300; academic level one = 429; academic level two = 524; and academic level three = 111) and geographical location (N_{North} = 348, N_{Center} = 299, N_{East} = 359, N_{South} = 363).

The Spanish standardization of the WAIS-III includes 14 well-known subtests: vocabulary, similarities, arithmetic, digit span, information, comprehension, letter-number series, picture completion, coding, block design, matrices, picture arrangement, symbol search, and object assembly.

Analyses

The method of correlated vectors is especially appropriate for comparing the vectors defined by the *g* loadings of a variety of tests and the standardized mean group differences (*d*) in those tests (Colom et al.; 2000, Jensen, 1998). This method must comply with several conditions (see Jensen for more details): The samples must be large and representative, the number of tests analyzed must be large enough, the tests must be diverse, the tests' reliability coefficients must be taken into account, and the values corresponding to the congruence coefficients among the factors of interest obtained from the groups compared should be higher than .90. The congruence coefficient (r_c) is an index of factor similarity. If the groups show identity of the *g* factor, combining the two vectors can increase the reliability of the vector of *g*-loadings (Jensen, 1998).

The statistical test of the hypothesis concerning mean group differences is the correlation between the vector of the tests' *g* loadings and the vector of standardized mean differences between the groups on each of the tests (*d*), taking the tests' reliability coefficients into account. The method for testing the hypothesis depends on the magnitudes of the group difference across tests that differ in their *g*-loadings. The Spearman rank-order correlation (r_s) of the column vector of subtests' *g* loadings with the vector of the sex differences (*d*) on the subtests indicates the degree to which *g* is related to the rank order of the sex differences on the various subtests. If the correlation is not statistically significant, then the standardized sex differences (*d*) are not related to general intelligence defined as *g*.

We performed a hierarchical factor analysis (Schmid-Leiman transformation) separately for males and females. In the Schmid-Leiman transformation (Schmid & Leiman, 1957), the higher order factors are allowed to account for as much

Table 1
Descriptive Data and Standardized Mean Differences (d)

WAIS-III subtests	Males			Females			
	M	*SD*	*N*	*M*	*SD*	*N*	*d*
1. Vocabulary	38.12	13.44	665	36.28	14.00	702	.13
2. Similarities	17.40	6.93	666	16.65	6.62	703	.11
3. Arithmetic	13.37	3.92	666	11.19	3.62	702	.58
4. Digit Span	15.46	4.75	666	14.16	4.44	703	.28
5. Information	17.32	5.88	666	14.85	5.99	703	.42
6. Comprehension	18.54	6.17	666	17.56	6.11	703	.16
7. Letter-Number	9.88	3.58	665	9.01	3.51	702	.25
8. Picture Completion	18.12	5.17	665	17.48	5.35	702	.12
9. Coding	64.58	24.94	661	60.26	27.11	702	.17
10. Block Design	40.17	14.68	662	35.23	14.47	701	.34
11. Matrices	16.33	6.28	666	14.61	6.40	703	.27
12. Picture Arrangement	12.93	5.89	665	11.80	5.81	701	.19
13. Symbol Search	29.75	11.86	661	27.44	12.06	702	.19
14. Object Assembly	30.48	10.64	664	28.82	10.42	702	.16

Note. The *d* values were computed by dividing the mean difference between the groups by their pooled within-group standard deviation.

of the correlation among the observed variables as possible, whereas the lower order factors are reduced to residual factors uncorrelated either to each other or to the higher order factors. Therefore, each factor represents the independent contribution of the factor in question (Carroll, 1993; Loehlin, 1992).

Besides the method of correlated vectors, still another method for examining the sex difference in psychometric *g* is to represent the sex difference on each of the subtests in terms of a point-biserial correlation among subtests' scores and the sex variable, and include these correlations within the full matrix of subtest intercorrelations for factor analysis. The result will reveal the factor loading of sex on each of the factors that emerges from the analysis, including *g*. The factor loading of sex is equivalent to the point-biserial correlation between *g* and the sex variable.

Results

The descriptive data are shown in Table 1. The standardized sex differences (*d*) used for subsequent study of the relationships with the *g* loadings are also shown.

Table 2
Correlation Matrix of the WAIS-III Subtests (Male Correlations at the Top Half, Female Correlations at the Bottom Half). Reliabilities along the Diagonal

Subtests	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Vocabulary	.95	.747	.643	.536	.710	.741	.611	.613	.582	.607	.653	.608	.586	.547
2. Similarities	.768	.89	.619	.541	.670	.701	.599	.633	.555	.604	.654	.635	.565	.557
3. Arithmetic	.601	.604	.88	.582	.668	.580	.665	.607	.579	.635	.703	.584	.608	.583
4. Digit Span	.581	.596	.637	.89	.505	.486	.753	.506	.582	.526	.569	.565	.584	.568
5. Information	.731	.704	.632	.567	.93	.653	.579	.593	.503	.615	.634	.596	.511	.525
6. Comprehension	.719	.703	.546	.520	.698	.85	.565	.553	.507	.498	.572	.583	.497	.507
7. Letter-Number	.643	.624	.680	.764	.619	.573	.91	.582	.669	.624	.661	.669	.663	.601
8. Picture completion	.624	.617	.558	.579	.615	.562	.653	.91	.624	.683	.728	.687	.636	.636
9. Coding	.622	.604	.581	.592	.552	.496	.705	.659	.82	.648	.657	.680	.761	.631
10. Block design	.595	.611	.596	.594	.597	.496	.681	.686	.684	.94	.755	.713	.678	.746
11. Matrices	.667	.692	.692	.640	.627	.563	.711	.700	.750	.776	.94	.757	.727	.691
12. Picture arrangement	.626	.622	.600	.574	.639	.573	.663	.674	.659	.671	.754	.86	.672	.696
13. Symbol search	.592	.576	.565	.536	.548	.490	.683	.617	.807	.668	.708	.666	.77	.676
14. Object assembly	.580	.565	.505	.515	.556	.489	.593	.616	.618	.743	.697	.660	.625	.68

Table 3
Male and Female g Factor Loadings Extracted after a Hierarchical Factor Analysis (Schmid-Leiman Transformation); Average g Loadings are also Presented

WAIS-III subtests	*g* loadings		Average *g* loadings
	Males	Females	
1. Vocabulary	.77	.77	.77
2. Similarities	.76	.76	.76
3. Arithmetic	.76	.75	.76
4. Digit Span	.74	.78	.76
5. Information	.73	.75	.74
6. Comprehension	.71	.69	.70
7. Letter-Number	.83	.86	.84
8. Picture completion	.74	.75	.74
9. Coding	.77	.78	.77
10. Block design	.76	.76	.76
11. Matrices	.81	.83	.82
12. Picture arrangement	.79	.76	.78
13. Symbol search	.77	.75	.76
14. Object assembly	.73	.69	.71
% Variance	57.86	58.5	

Table 2 presents the correlation matrix, separately for males and females. Subtests reliabilities are also included.

A Schmid-Leiman hierarchical factor analysis was computed separately for females and males. The *g* factor was represented by the higher order factor. Table 3 shows the *g* loadings for males and females. The congruence coefficient computed from the *g* factor loadings in Table 3 for males and females was .999. Hence, the *g* factor is the same, irrespective of sex, so the average *g* loadings can be computed to apply the method of correlated vectors.

The Spearman rank-order correlation between the vector of *g* loadings and the vector of the standardized sex differences (*d*) was r_s = .059 (p = .840), a value suggesting a null sex difference in *g* (Pearson r = –.008, p = .979, partial correlation controlling for r_{xx} = –.0981, p = .750). Figure 2 shows the scatter diagram corresponding to the correlation between the *g* and *d* vectors. This results in the failure to reject the null hypothesis of no sex differences in general intelligence defined as *g*.

The point-biserial correlations between sex and the WAIS-III subtests were also computed. These correlations were included within the full matrix of subtests correlations for factor analysis. The resulting *g* loading of sex was .159.

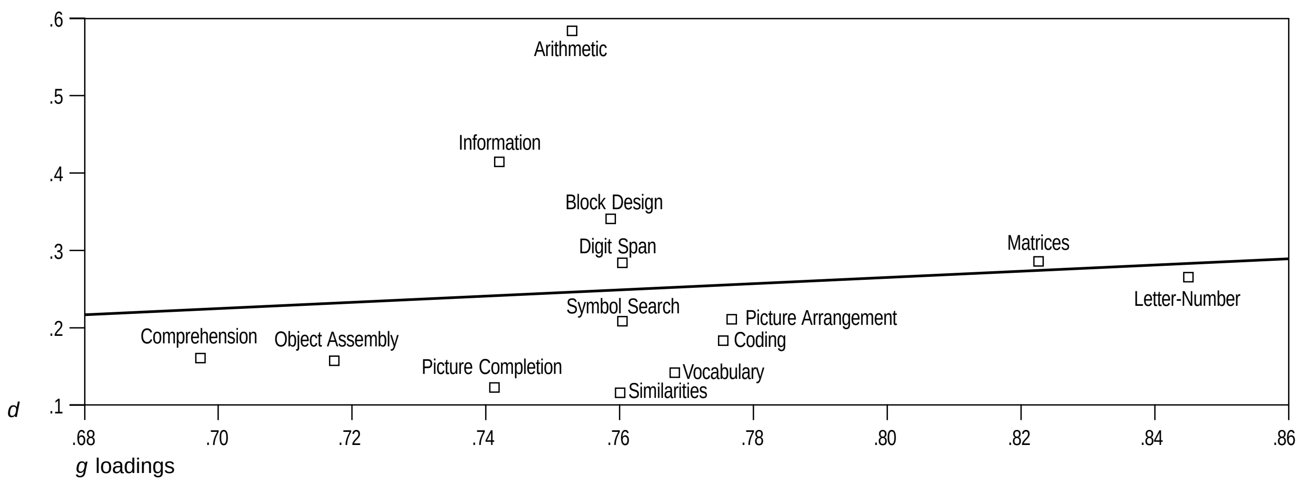

Figure 2. A scatter diagram of the correlation of the standardized sex differences (*d*) with the WAIS-III subtests plotted as a function of the subtests' *g* loadings. Spearman r = .059, p = .840; Pearson r = –.008, p = .979; Partial correlation controlling for subtests' reliabilities = –.0981, p = .750.

Discussion

Jensen (1998) applied the method of correlated vectors for the comparison of the *g*-loadings in several cognitive batteries (WISC-R, WAIS, GATB, ASVAB, and the British Ability Scales, BAS) with the standardized sex difference (*d*) on the scales included in those batteries. The correlations found by Jensen (1998, p. 539) were .346, –.036, .024, .127, and .103, respectively. He also computed the *g* loading of sex in those cognitive batteries, obtaining the values .094, .006, –.255, .180, and –.001, respectively. Jensen's (p. 540) main conclusion was: "The method of correlated vectors shows that in no case is there a correlation between subtests' *g*-loadings and the mean sex differences on the various subtests […] the *g*-loadings of the sex differences are all quite small."

Colom et al. (2000) found a negligible sex difference in *g* after the largest sample on which a sex difference in *g* had ever been tested (N = 10,475). The Pearson r of the column vector of subtests' *g* loadings with the vector of the sex differences (*d*) on the subtests was .122 (p = .721). With the vector of reliability coefficients partialled out, the *g* and *d* vectors were correlated .051. The Spearman rank order correlation was .000 (p = .999). Furthermore, the *g* loading of sex was .216. Therefore, their findings are entirely consistent with those using quite different batteries and subject samples.

Aluja et al. (2000) found an average *g*-loading of sex of –.172, using two samples of 670 and 887 young adolescents. Thus, the value was consistent with previous findings.

Considering all the available empirical evidence, including that we report in the present study after the Spanish standardization sample of the WAIS-III, the average correlation between *g* and *d* is .09, whereas the average *g*-loading of the sex variable is .02. Therefore, it is clear that the standardized sex difference in typical IQ tests cannot be attributed to general intelligence defined as *g* (Aluja et al., 2000, Colom et al., 2000, Jensen, 1998).

It is extremely important to gather cumulative evidence from different batteries and subject samples because, as Carroll (1997, p. 31) has stated, "*g* [...] is likely to be present, in some degree, in nearly all measures of cognitive ability. Furthermore, it is an important factor, because on the average, over many studies of cognitive ability tests, it is found to constitute more than half of the total common factor variance in a test."

New pieces of evidence must be considered, because there is an increasing number of studies claiming that the sex difference in general intelligence is "real" (Ankey, 1992, 1995; Lynn, 1994, 1998, 1999; Rushton, 1992). The present study shows that the supposed sex difference is a difference in "intelligence in general," but not in "general intelligence" (Aluja et al., 2000; Colom et al., 2000; Jensen, 1998).

The mean *d* that can be calculated from the Table 1 of the present study is 0.241. This value translates into 3.6 IQ points favoring males, not so far from the 3.8 IQ points reported by Lynn (1994, 1999). The important issue is that the method of correlated vectors contradicts the conclusion that could be derived from the simple summation of the standardized mean group differences (*d*). Because of the greater scientific adequacy of the method of correlated vectors to test the null hypothesis concerning sex differences in general intelligence defined as *g*, we can conclude that there is no sex difference in general intelligence.

The null sex difference in *g* suggests that: (a) The factor (*g*) that is present in nearly all measures of cognitive ability (and that accounts for more than half of the total common factor variance in a test) does not differ between sexes; (b) non-*g* factors and/or test specificity are responsible for the observed cognitive sex differences; and (c) the "paradox"–the findings of larger male brain, the association of brain size with IQ, and the absence of a sex difference in overall IQ–is not relevant to the problem of whether or not is there a sex difference in general intelligence, because *there is no sex difference in general intelligence*.

The practical importance of the null sex difference in *g* is directly related to its social correlates. A difference between the means of two population groups has a quite different kind of consequence than does the very same size difference when obtained between two individuals on the same scale. For groups, the most important consequence of a group difference in means is of a statistical nature. The consequences of population differences in IQ are of greater importance than are most other measurable characteristics that show comparable population differences (considering all the important social correlates of IQ). Because the percentage of individuals who fall in a given *SD* range decreases so rapidly as one moves away from the mean and toward either tail of the normal distribution, it becomes obvious that the populations are disproportionately represented in the upper and lower tails (Figure 1). To the extent that there are different selection thresholds for the level of IQ required for certain levels of educational attainment, or for admission into colleges, occupations, or specialized training programs, population groups that differ in mean IQ will be represented unequally in the selection outcome. This is a direct consequence of the correlation between IQ and these socially significant variables within each population.

Given that the main ingredient of the association between IQ and these social correlates is *g*, and given that there is no sex difference in *g*, it must be concluded that the average IQ sex difference is attributable (by default) to group factors and/or to test specificity. Therefore, the functional difference between the sexes in the real settings where *g* is functioning must be expected to be negligible. This evidence *must be* considered in the practical assessment of intelligence.

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