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# Ability level differentiation in adult males and females

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Despite the increasing importance of the ability-level differentiation hypothesis, no study has been conducted to clarify the role played by sex regarding this issue. A battery of cognitive tests was administered to a sample of 10,247 participants (6,068 males and 4,179 females). Results show a differentiation effect in males (around 2%) but not in females. Therefore, the ability-level differentiation hypothesis is substantiated for males only.

*Diferenciación por nivel de habilidad en varones y mujeres adultos.* A pesar de la importancia creciente de la hipótesis de la diferenciación por nivel, ningún estudio se ha dirigido a clarificar el papel que la variable sexo juega con respecto a este asunto. En el presente estudio, una batería de pruebas cognitivas se administró a una muestra de 10.247 participantes (6.068 varones y 4.179 mujeres). Se encuentra un efecto de diferenciación en hombres (alrededor de un 2%), que no se replica en mujeres. Por consiguiente, la hipótesis de la diferenciación por nivel de habilidad sólo se mantiene en la muestra de varones.

A substantial percentage of variance in human mental ability can be accounted for by a general intelligence factor (Carroll, 1993; Jensen, 1998; Spearman, 1927). The changes in the structure of cognitive abilities related to ability-level have become a central topic in current research on human intelligence (Deary, Egan, Gibson, Austin, Brand, and Kellaghan, 1996; Detterman & Daniel, 1989; Juan-Espinosa, 1997). The *ability-level differentiation hypothesis* states that the higher the level of *g*, the less is the amount of variance accounted for by *g*.

The history of testing the ability-level differentiation hypothesis is characterized by contradictory results. Some studies have supported it (Abad, Colom, Juan-Espinosa, & García, in press; Detterman & Daniel, 1989; Legree, Pifer, and Grafton, 1996; Lynn, 1992), while others do not (Fogarty and Stankov, 1995). Such disparity of results has been attributed to methodological problems, as the inappropriate use of the correction for restriction of range (Jensen, 1998). Using a methodology trying to surpass such problems, Deary et al. (1996) found only a small difference between low and high ability-level groups (around 2%).

On the other hand, regarding the changes in the structure of intelligence across the life-span, the *age-differentiation hypothesis*, as coined by Garrett (1946), predicts a decrease in the variance accounted for by *g* from childhood to adolescence and the corresponding increase in the number and importance of specific factors. Nevertheless, the *age de-differentiation hypothesis* states that the reverse phenomenon is expected from early maturity to senescence. Therefore, an increase in the importance of *g* and a decrease in the number and importance of the remaining abilities are predicted (Balinsky, 1941). Recently, Juan-Espinosa, García, Escorial, Rebollo, Colom, and Abad (2002) have raised *the indifferentiation hypothesis* as a more appropriate view of the changes in the structure of intelligence across the life-span. This hypothesis states that neither the variance accounted for by *g* or the main cognitive abilities, nor the number of ability factors, will change along the life span.

The indifferentiation hypothesis is supported irrespective of the sex in adult samples (Escorial, Juan-Espinosa, García, Rebollo, Colom, in press). However, no study has been conducted to clarify the role of sex in the ability-level differentiation phenomenon.

Recently, Abad et al., (in press) have tested the ability-level differentiation hypothesis using the same database analysed in the current study. A differentiation effect around 2% was found in the total sample. When the differentiation effect has been verified for the total sample, then we can tested if such effect given along other variables, for example sex. Therefore, the main purpose of the present study is to clarify whether or not ability differentiation applies across sex. Thus, the main question to answer is: does the *g* factor change due to ability-level irrespective of the sex variable?

## Method

### *Participants*

The sample comprised 10,247 applicants for admission to a private university (6,068 males and 4,179 females). Note that most of them did not reach the score level required for admission to the State University. Therefore, the sample is more representative of the general population than samples taken from applicants to the State University. The mean age was 23.12 years (S.D.= 2.17).

### *Measures*

The battery was applied collectively in groups of 30 subjects each. The battery comprised four psychometric intelligence tests.

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Three of them were from the Primary Mental Abilities (PMA) Battery: Inductive Reasoning (Split-Half reliability= 0.92), Vocabulary (Split-half reliability= 0.91), and Spatial Rotation (Test-retest reliability= 0.73). The fourth test was developed in Spain and is called «Monedas» (Split-Half reliability= 0.91). «Monedas» is a test based on the combination of the size of several coins, the digits put inside the coins to specify the number of them that the subject must take into account, and some numerical operations to make the necessary calculations (adding, subtracting, and so forth) to arrive at a given response. «Monedas» correlates r= +.64 with the Numerical Ability (NA) Scale from the DAT.

*Statistical Procedures for Subgroup Selection*

Deary et al's (1996) methodology to select groups with the desired distribution (normal distribution and similar variance) as well as with different levels of performance (low and high) was used. Thus, we avoided using the inadequate procedure of correction for restriction of range to equalise the variances in the two ability-level groups (Deary et al., 1996; Jensen, 1998). The procedure was as follows (see Deary et al., 1996, for details)[1]:

(i) Select an incomplete group (low or high) at random, with equal probability for each group.
(ii) Generate a random value ($y$), from a normal distribution with mean and variance specific to the selected group (low or high). The algorithm described by Brysbaert (1991) to generate the normal distribution was used.
(iii) Extract the $x_i$ (test score for subject $i$) from the empirical distribution, matching $y$ most closely, minimising the quantity $C(x_i\text{-}y)$. If the minimised value is less than some specified tolerance, then the subject $i$ is placed in the selected group, and is thereafter unavailable for selection. If the tolerance is exceeded, a mismatch for the specified group is recorded. A group is complete when $m$ mismatches are recorded, $m$ being specified by the user.
(iv) The procedure is finished when the two groups are complete.

Such a procedure was applied for each test. The standard deviations of the groups were a half of the total group (0.5 because the variables were first standardised). The group means fall 1 standard deviation from the mean of the total group (0); the means for low scorers being –1 and for high scorers +1.

*Analyses*

We analysed the percentage of variance accounted for by the first unrotated principal component in every group. According to Jensen and Weng (1994) this is a good estimate of the *g* factor. The selection test is both, included and omitted in the factor analyses, to have comparative evidence.

Factor comparisons call for an assurance that the same factor is being extracted in the two groups (Cattell, 1978). The congruence coefficient ($r_c$) is an index of factor similarity. A value of $r_c$ above +0.90 is considered as a high degree of factor similarity; a value greater than +0.95 is generally interpreted as practical identity of the factor (Jensen, 1998). Two kinds of congruence coefficients were performed in order to compare the *g* factor: ability groups within sex and between the sexes.

Given that the reliability coefficients of the tests have not been determined directly, each test's communality (the proportion of its total variance accounted for by the common factors) is used as a lower-bound estimate of the tests' reliability (see Nyborg & Jensen, 2000, for details). Thus, for instance, when the «Monedas» test was used as a selection test, factor analyses including this test were computed for low and high ability groups. Monedas´s communality after these analyses was used as an estimate of its reliability. Congruence coefficients were computed between the reliability vectors corresponding to the low and the high ability groups.

## Results

The congruence coefficients were always higher than .95. Therefore, the *g* factor is the same irrespective of ability-level or sex (Colom, Juan-Espinosa, Abad & García, 2000). Table 1 shows the descriptive statistics for every subgroup of males and females. The empirical distributions fit almost perfectly with the expectations.

Table 2 presents the variance accounted for by the *g* factor as well as the reliability estimates and the skewness of every test in both sexes. Concerning the male sample, a meagre differentiation effect is observed. This is found irrespective of the inclusion or not of the selection test. However, this is not true for all the tests analysed. With respect to the female sample, the mean difference between the low and high ability group is negligible, especially when the selection test is excluded.

These results are not influenced by the subtests' reliabilities (Escorial, Rebollo, García, Colom, Abad & Juan-Espinosa, in press) given that the congruence coefficients between the reliability vectors of low and high ability groups (see table 2) were

*Table 1*
Descriptive statistics (S.D.= Standard Deviation) for sex and ability-level group

| SEX | SELECTION TEST | LOW ABILITY GROUP N | LOW ABILITY GROUP MEAN | LOW ABILITY GROUP S.D. | HIGH ABILITY GROUP N | HIGH ABILITY GROUP MEAN | HIGH ABILITY GROUP S.D. |
|---|---|---|---|---|---|---|---|
| **Males** | PMA-R | 260 | -1 | .51 | 272 | 1 | .5 |
| | PMA-V | 1399 | -1 | .5 | 1292 | 1 | .5 |
| | PMA-S | 1212 | -1 | .5 | 1334 | .98 | .5 |
| | MONEDAS | 1278 | -1 | .51 | 979 | 1 | .5 |
| **Females** | PMA-R | 102 | -1 | .51 | 111 | 1.1 | .49 |
| | PMA-V | 1144 | -1 | .5 | 1029 | 1 | .51 |
| | PMA-S | 833 | -1 | .48 | 847 | .98 | .47 |
| | MONEDAS | 946 | -1 | .5 | 982 | .98 | .52 |

*Table 2*
Percentages of variance accounted for by g excluding the selection test (and including the selection test between parenthesis) (% *g*) , reliability estimates ($r_{xx}$) for low and high ability groups, and subtests' skewness in males and females

| SEX | SELECTION TEST | LOW ABILITY GROUP | | HIGH ABILITY GROUP | | Skewness |
|---|---|---|---|---|---|---|
| | | % *g* | $r_{xx}$ | % *g* | $r_{xx}$ | |
| **Males** | PMA-R | 43.580 (38.656) | .481 | 46.989 (41.375) | .460 | -.481 |
| | PMA-V | 57.744 (45.345) | .165 | 53.677 (41.742) | .136 | .057 |
| | PMA-S | 54.250 (44.322) | .282 | 51.387 (40.926) | .216 | -.141 |
| | MONEDAS | 50.138 (43.366) | .416 | 47.052 (38.612) | .311 | -.862 |
| | *MEAN* | *51.428 (42.922)* | *.336* | *49.776 (40.663)* | *.281* | |
| **Females** | PMA-R | 43.393 (36.484) | .387 | 49.091 (39.563) | .251 | -.565 |
| | PMA-V | 58.003 (45.310) | .149 | 58.894 (45.059) | .07 | .070 |
| | PMA-S | 53.743 (43.123) | .235 | 50.222 (39.724) | .198 | -.003 |
| | MONEDAS | 49.794 (42.797) | .402 | 49.628 (39.619) | .233 | -.398 |
| | *MEAN* | *51.233 (41.928)* | *.293* | *51.958 (40.991)* | *.188* | |

+.99 in both sexes. Another potential bias that must be considered is the test's skewness (Legree et al., 1996). Fortunately, the tests have no great skewness values either in males or in females (see table 2). Therefore, skewness is hardly a relevant issue in the present study.

## Discussion

The differentiation hypothesis was substantiated for males but not for females. Although a slight differentiation effect was observed in males, such an effect vanished for females. Results for the male sample closely resembles those of Deary et al. (1996), and Abad et al. (in press). There is a mean difference of around 2% between the low and high ability groups. It is noteworthy that the results are not by products of the tests' differences in asymmetry or reliability.

What are the reasons for the different effect found in males and females? It could be due to global differences in the ability-level, but previous evidences do not show sex differences in the *g* factor (Colom et al., 2000; Colom & Andrés-Pueyo, 1999), and in both sexes *g* accounts for by the same variance (around 49%). The role of other cognitive abilities (Verbal, Visual and so forth) cannot be explored in this paper since the low numbers of tests do not allow us to extract these factors independently from *g*.

Related to the ability-level, the homogeneity of the sample could also be a reason of the observed results. It is expected that samples less homogeneous present a larger differentiation effect. But Levene's test ($\alpha$= .01) shows that there are no differences in the variability in any test between males and females. Similar skewness values across sexes reinforce this view.

Recently, Colom, Abad, García, and Juan-Espinosa (in press) pointed out that education could be the main cause for the ability-level differentiation phenomenon. They found that *g* accounts for more variance in the less educated people when are compared to more educated people. So, the ability-level differentiation effect could be due to the well-known relationship between intelligence and the educational level attained. Less intelligence people spends less years on school and, moreover, take less advantage from the education received (Jensen, 1998). However, in samples with the same educational level, differentiation effect can also be observed (Deary et al., 1996; Jensen, in press). In the current study, males and females have the same official educational level. But, the key could be the acquired education instead of the official educational level. If males were less homogeneous in their acquired education (measured, for instance, after knowledge tests) than females, and the latter were very homogeneous, it could explain our results. Unfortunately, we do not have the appropriate data to test this statement.

To sum up, what our results claim is that the previous findings about the ability-level differentiation hypothesis could be biased by the specific differentiation male effect. As far as we know, the present study is the first one revealing this effect of sex. Therefore, the sex variable must be considered when testing the ability-level differentiation hypothesis, although the reasons for the different effect found in males and females remains unclear.

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## Notes

[1] The computer program is available upon request from the first author.

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