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The differentiation hypothesis and the Flynn effect

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Many studies have shown that IQs have been increasing over the last half century. These increases have come to be known as «the Flynn effect». The «Flynn effect» represents a difference on ability-level between groups of the same age but different cohort. The ability-level differentiation hypothesis represents a difference on the relevance of cognitive factors between groups of high and low ability. Hence, it should be possible to imitate the ability-level differentiation effect by comparing groups of the same age but different cohort. The indifferentiation hypothesis represents no differences on the relevance of cognitive abilities in all age groups within the same cohort. The aim of the present study is to test the relationships between these phenomena. For this purpose we analyzed the American standardisation samples of the WISC, WISC-R and WISC-III. Results support the link between the Flynn effect and the differentiation hypothesis. Also, reported evidence replicate previous findings supporting the indifferentiation hypothesis. Implications for the assessment of the intelligence are discussed.

La hipótesis de la diferenciación y el efecto Flynn. Muchos estudios han mostrado que las puntuaciones en CI se han venido incrementando durante la última mitad del siglo pasado. Este incremento es conocido como «Efecto Flynn». El efecto Flynn representa una diferencia en el nivel cognitivo entre grupos de la misma edad pero de diferentes cohortes. La hipótesis de la diferenciación por nivel representa una diferencia en la relevancia de los factores cognitivos entre grupos de alto y bajo nivel de habilidad. Por tanto, puede ser posible imitar el efecto de la diferenciación por nivel mediante la comparación de grupos de la misma edad pero de diferente cohorte. La hipótesis de la indiferenciación representa la ausencia de diferencias en la relevancia de los factores cognitivos en todos los grupos de edad dentro de la misma cohorte. El objetivo del presente estudio es comprobar la relación entre estos fenómenos. Para ello, se analizarán las muestras de estandarización americanas del WISC, WISC-R y WISC-III. Los resultados mantienen la relación entre el Efecto Flynn y la hipótesis de la diferenciación. También aportan evidencia replican resultados previos que permiten mantener la hipótesis de la indiferenciación. Implicaciones para la evaluación de la inteligencia son discutidas.

Many studies have shown that IQs have been increasing over the last half century. These increases (coined as «the Flynn effect») have been reported in a wide number of countries (e.g., United States, Japan, Britain, Australia, New Zealand; Flynn, 1987), including Spain (Colom, Andrés-Pueyo and Juan-Espinosa, 1998), and non-western areas as Africa (Daley, Whaley, Sigman, Espinosa and Neumann, 2003), although there is some research that suggests that the increments of the Flynn effect have either slowed down or stopped (Teasdale and Owen, 2000).

Whether the secular increase on intelligence may be attributed to the *g* factor or to specific factors is an unresolved question. Rushton (1999) argued that the increments were due to the Crystallized component of the Wechsler's scales instead of the *g* factor. Must, Must, and Raudik (2003) also defended a similar position since they found a negative correlation between a vector of secular gains in three literacy subscales for the Estonian population, and the loadings on the first principal component. However, Flynn (1999) reanalysed Rushton's (1999) data, and ranked the WISC (Wechsler Intelligence Scale for Children) subtests in terms of their correlations with Raven's g, thus injecting a fluid bias. As a result of this, the correlation between *g* loadings and IQ gains turned out to be positive. Colom, Juan-Espinosa, and García (2001) also found a positive correlation (+.707; p= .022) between the vector of loadings on *g*, and the vector of generational increments for the subtests of the DAT (Differential Aptitude Tests) battery from 1975 to 1995 in the Spanish population.

A major development within the theory of *g* is the «differentiation theory». Applying this theory to the ability-level differences, it is expected that the higher the level of g, the lesser the amount of variance in a battery of cognitive tests accounted for by the *g* factor. This phenomenon was first observed by Spearman (1927), and it has been replicated in different samples (Deary, Egan, Gibson, Austin, Brand and Kellaghan, 1996; Detterman and Daniels, 1989; Legree, Pifer and Grafton, 1996; Lynn, 1992). Abad, Colom, Juan-Espinosa and García (2003) found a larger differentiation effect on a «fluid» battery (i.e. with stronger relationships with the *g* factor; Carroll, 1993) than on a

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«crystallized» battery (the WAIS-III; Wechsler Adult Intelligence Scales-Third version). Similarly, Jensen (2003) reported a negative relationship between the size of the *g* loadings and the differentiation effects observed across subtests.

With respect to age, the differentiation hypothesis states an increasing differentiation of general ability and the development of special abilities from childhood to early maturity. In the course of mental development *g* would become increasingly invested in specific abilities. Intelligence would change in its organisation as age increases from a single, general, relation-perceiving ability to specific group of abilities (Garrett, 1946). Therefore, older adolescents are supposed to have more diversified abilities, with more of the total variance in their abilities located in non-g factors, as the investment theory also predicts (Cattell, 1987). From early maturity to late adulthood, the reverse tendency (named as «age dedifferentiation hypothesis») was postulated. An increase of the variance accounted for by g, as well as a reduction in the number of specific abilities would be expected (Balinsky, 1941).

Regarding the changes in the percentages of variance along the life-span, the evidences have been largely negative (e.g. Bickley, Keith and Wolfe, 1995; Carroll, 1993; Deary et al, 1996). Thus, Juan-Espinosa, García, Escorial, Rebollo, Colom and Abad (2002) proposed the term «*indifferentiation hypothesis*» to describe better this pattern of stability. 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. As they write: «This perspective leads to the replacement of the investment metaphor with an anatomical metaphor: As the human skeleton, there is a basic structure of intelligence that is present early in life. This basic structure does not change at all, although, like the human bones, the cognitive abilities grow up and decline at different periods of life» (p. 406).

The «Flynn effect» represents a difference on ability-level between groups of the same age but different cohort. The ability-level differentiation hypothesis represents a difference on the relevance of cognitive factors between groups of high and low ability. Hence, it should be possible to imitate the ability-level differentiation effect by comparing groups of the same age but different cohort. Thus, it is expected that the percentages of variance observed in different cohorts reflect the differences between high and low ability groups. Some studies have linked the «Flynn effect» to the ability-level differentiation hypothesis in France (Lynn, & Cooper, 1993), Japan (Lynn and Cooper, 1994), and the United States of America (Kane, 2000; Kane and Oakland, 2000). All of them found the predicted pattern, being the correlations lower in the recent cohorts than in the oldest ones. On the other hand, the indifferentiation hypothesis predicts an absence of differences on the relevance of cognitive factors between age groups. This pattern is expected irrespective of the cohort analyzed (Juan-Espinosa et al, 2002).

Method

Subjects and measures

The American standardisation samples of the Wechsler Intelligence Scale for Children (WISC; Wechsler, 1949), the Wechsler Intelligence Scale for Children-Revised (WISC-R; Wechsler, 1974), and the Wechsler Intelligence Scale for Children-Third version (WISC-III; Wechsler, 1991) were analysed. The following age groups were considered in the present study: WISC (7 and 13), WISC-R (6, 7, 8, 9, 10, 11, 12, 13, 14, 15 and 16) and WISC-III (6, 7, 8, 9, 10, 11, 12, 13, 14, 15 and 16). The number of subjects was 200 in each age group. The standardisation processes comply in each age group with almost equally number of boys and girls.

Although some items were changed in the successive versions, those changes were minimum, and the manuals inform us of high correlations between the successive versions. Thus, the correlation between the WISC and the WISC-R was .891, and between the WISC-R and the WISC-III was .887. These pieces of data support the comparisons across scales.

Analysis

Extracting *g* as a second-order factor requires a minimum of nine tests from which at least three primary factors can be obtained (Jensen and Weng, 1994). The three batteries match those requisites. The correlation matrices were used as input data. The extraction method was principal components (PC) followed by Promax rotation. Then, a Schmid-Leiman hierarchical factor analysis was performed to compute the percentage of variance accounted for by the *g* factor (see Loehlin, 1992; Schmid and Leiman, 1957). This procedure allows us to partial out the variance due to the *g* factor only. Although this procedure is also optimal to extract other cognitive factors, only g will be analysed because the hypotheses tested in the present paper are mainly focused on the *g* factor.

Before comparing age groups, it is necessary to know if the factors compared are the same irrespective of the age group (McArdle, 1996). The congruence coefficient (rc) was used for that purpose (Cattell, 1978). A value of rc above +.90 is considered as a high degree of factor similarity; a value greater than +.95 is generally interpreted as a practical identity of the factor (Jensen, 1998). As long as the inspection of the reliability coefficients, this preliminary analyses are also necessary to test if the changes in the items content have substantially modified the subtests. Note that the congruence coefficient is used to compare age groups within the same cohort.

Finally, the significance of the differences among the eigenvalues for the different age groups can be contrasted by the F ratio of the low/high groups. This analysis informs us about the significance of the changes in the percentage of variance (Escorial, Juan-Espinosa, García, Rebollo and Colom, 2003; Jensen, 2003).

Results

Firstly, the 7 and 13 age groups of the WISC and the WISC-III were compared. It was selected the WISC-III instead of the WISC-R in order to maximize the likelihood of finding differences. The eigenvalues and percentage of variance (between parenthesis) explained by the *g* factor were 5.07 (46.07), and 4.99 (45.33) for the WISC, and 4.76 (43.23) and 4.64 (42.14) for the WISC-III, for the 7 and 13 age groups, respectively. The F ratio of the eigenvalues for the same age and different cohort were both significant ($p<0.05$). However, the differences within each cohort were negligible.

Table 1 compares the variance accounted for by the *g* factor between the six and the sixteen years old for the WISC-R, and the WISC-III cognitive batteries. Comparing the same age group in the two cohorts, the F ratio of the eigenvalues was always significant for all ages groups except for the 6, 10, and 16 years. Besides, the F ratio of the mean eigenvalue between the WISC-R and the WISC-III was also significant. A special case was the 15 age group where the *g* factor explained more variance in the WAIS-III. Again, there were no general differences in the F ratio within each cohort.

As it has been noted in the analysis section, it is necessary to assure the comparability of the *g* factor before those results were seriously observed. In this sense, all congruence coefficients between every pair of compared age groups were higher than .95. Besides, congruence coefficients comparing the vectors of reliability coefficients were also computed. They also reach values higher than .95. Therefore, neither substantial changes in the loadings nor differences on the reliability coefficients explain those results.

Discussion

The present study intended to link two phenomena related to the *g* theory (Jensen, 1998), the «Flynn effect» and the «differentiation hypothesis». Results observed in the three cohorts from six to sixteen years old replicate previous findings about the relationships between both phenomena (Lynn and Cooper, 1993; 1994; Kane, 2000; Kane and Oakland, 2000). Moreover, note that the gap between batteries is about 40 years, enough to observe differences on ability level between cohorts.

This fact suggests that common factors could influence the secular increase in intelligence scores as well as the observed differences on the cognitive structure between ability-level groups, suggesting that the mechanism that leads to the Flynn effect is the same as that which leads to changes in the structure of intelligence between ability levels. This would support the Flynn's (1999) statement that an environmental explanation of an IQ gap between contemporary human populations needs only posit that the average environment for the high-level group in 1949, matches the quality of the average environment for general population in 1991.

Now, it is commonly assumed that the secular increase could be due to a synergic effect of different factors (i.e. improvement in the nutrition and health care, schooling, a powerful cognitive stimulation; Colom, Lluis-Font and Andrés-Pueyo, 2005). A careful analysis of psychological and economical data in many countries revealed that the improvements in the quality of life (caused by the economical and technical advances, especially in western countries) were behind of the increments in the cognitive potential (Fernández-Ballesteros, Juan-Espinosa and Abad, 2001), and their practical repercussions (Cocodia, Kim, Shin, Kim, Ee, Wee and Howard, 2003). Those considerations should be taking into account in the development processes of psychological and educational assessment techniques (Moreno, Martínez and Muñiz, 2004).

On the other hand, the indifferentiation hypothesis receives support in three different cohorts, since most of the changes in the variance from the childhood to the adolescence were non-significant in any battery (Juan-Espinosa et al, 2002; Carroll, 1993). It is to say, neither the secular increase in intelligence nor other cohort variables seem to alter the importance of the *g* factor from the childhood to the adolescence. This pattern of stability is found irrespective of the cohort analysed, reinforcing the view of a basic and unmodified structure of intelligence across the life-span.

The indifferentiation hypothesis has relevant practical implications. First of all, it can be assumed that Wechsler batteries are measuring the same *g* factor across all age groups. This being true, social correlates of the Wechsler's scales as the prediction of the educational achievement or the likelihood of being out from the school (e.g., Neisser, Boodoo, Bouchard, Boykin, Brody, Ceci, Halpern, Loehlin, Perloff, Sternberg and Urbina, 1996) would be mostly due to the *g* factor (Jensen, 1998). However, the same cannot be said of the comparison across cohorts. The youngest cohorts depend more on non-g factors to achieve a higher performance level. It would imply that the measure of the cognitive potential in more recent cohorts should incorporate other tests with high loadings on those specific factors.

Table 1
Eigenvalues (l**)** and percentages of variance (%) accounted for by *g* in all age groups of the WISC-R, and the WISC-III cognitive batteries

Battery		**Age groups**											**Mean**
		6	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	
WISC-R	λ	5.36	5.27	5.59	5.79	5.35	5.53	5.84	5.41	5.64	5.09	5.37	5.47
(1974)	%	44.74	43.94	46.60	48.26	44.59	46.15	48.69	45.13	47.03	42.45	44.80	45.67
WISC-III	λ	5.27	4.74	4.97	4.99	5.08	5.01	5.43	5.07	5.07	6.20	5.26	5.19
(1991)	%	43.94	39.51	41.45	41.63	42.38	41.76	45.32	42.46	42.26	51.70	43.89	43.3

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