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A secular decline in Spearman's g : evidence from the WAIS, WAIS-R and WAIS-III

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Abstract

Spearman's law of diminishing returns posits that general intelligence, or simply g , exerts a lesser influence in high-IQ groups than in low-IQ groups. The present study examined this phenomenon across populations and time, using the standardizations of the WAIS, WAIS-R and WAIS-III. Average intercorrelations were compared across each of the standardization samples. Results indicate that a significant decline in the statistical power of Spearman's g has occurred on a secular level, over a 46-year period. The largest decline seems to have occurred between 1955 (date of publication of the WAIS) and 1981 (date of publication for the WAIS-R). Maximum likelihood analysis confirmed the initial findings. Possible explanations for the differentiation of cognitive abilities are offered. © 2000 Elsevier Science Ltd. All rights reserved.

1. Introduction

In *The abilities of man*, Charles Spearman noted that correlations between test scores vary according to intellectual ability. That is, test correlations are higher among low-IQ individuals than among high-IQ individuals. He chose not to investigate the phenomenon systematically, instead offering post hoc comments on the "curious matter that has arisen". In 1927, Spearman, using his own data and results from other studies, remarked:

Now, all the changes we have been considering follow a general rule. The correlations

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always become smaller — showing the influence of *g* on any ability to grow less — in just the classes of person which, on the whole, possess this *g* more abundantly. The rule is, then, that the more “energy” a person has available already, the less advantage accrues to his ability from further increments of it. (p. 219)

Drawn to an industrial metaphor appropriate to the times, Spearman compared *g* to a steam engine, noting that an engineer does not achieve a doubling of a ship’s speed by doubling the coal in the boiler (p. 219). Spearman did not write extensively on this observation, only mentioning it in light of the “diminishing returns of *g*” (p. 220). Detterman and Daniel (1989) rediscovered Spearman’s law of diminishing returns when they divided the standardization samples of the WISC-R and WAIS-R into five ability groups. They found that the average intercorrelation between subtests declined significantly as ability increased. For the low-IQ group (below 78), intercorrelations averaged 0.56, uncorrected for range restriction; for the high-IQ group (above 122), intercorrelations averaged 0.22. These results confirmed Spearman’s law of diminishing returns and suggest that the relationship between *g* and test performance is stronger for lower-IQ testees. Other studies (see Brand, 1996) have found similar results, confirming that *g* exerts a greater influence, or accounts for a greater proportion of variance in test scores, at the lower end of the intellectual spectrum. The variant nature of *g*, and the accompanying law of diminishing returns, may explain the differentiation in ability often observed in high-IQ groups (Brand, 1996; Garrett, 1946).

It has also been well documented (e.g. Flynn, 1987) that the mean IQ of the populations of a number of nations has increased by approximately 15 IQ points over the last few decades. This increase has occurred conjointly with economic development. A reasonable inference from the ‘Flynn effect’ is that the influence of Spearman’s *g* should be falling concomitant with the increases in IQ. In other words, Spearman’s law of diminishing returns should also occur on a secular level. The magnitude of test intercorrelations are taken as an indicant of the strength of Spearman’s *g*; therefore, by observing test intercorrelations across time, the identification of a secular decline in Spearman’s *g* should be a reasonably straightforward task. Lynn and Cooper (1993) identified such a pattern over a 26-year period, between 1965 and 1981, in France. Certainly, an intriguing question is whether the declining pattern has continued to the present. Perhaps the best source of data to explore this particular phenomenon is the American version of the WAIS and its subsequent revisions.

The purpose of the present study is to investigate Spearman’s law of diminishing returns across populations and time. Specifically, this study will test the hypothesis of a secular decline in *g* from data obtained from the WAIS, WAIS-R and WAIS-III.

2. Method

The WAIS standardization was performed using 1700 American adults selected as representative of the population on the basis of the 1950 US census. There were seven different age groups, ranging from 16 to 64 years, with 200 participants at the three age levels between 16 and 24 years and 300 participants at each subsequent age level. An equal number of males and females participated in the standardization. Unlike the WISC, which included only Whites

in the standardization sample, the WAIS included non-Whites (e.g. Blacks, American Indians, Asians and Puerto Ricans). The WAIS-R standardization included 1880 adults between the ages of 16 and 74 years. An equal number of males and females were at each age level. The sample was stratified on age, race, geographic region, SES and parent education. Within each age group, participants were selected as to match the 1970 US census. The standardization of the WAIS-R has been termed “superior” and “excellent” (Sattler, 1994). The WAIS-III is the latest revision of the Wechsler scales and represents an attempt to sample a greater array of cognitive abilities. The WAIS-III standardization sample included 1250 individuals ranging from 16 to 89 years of age. Thirteen age levels are represented, with between 75 and 100 individuals at each level. Like its antecedents, the WAIS-III standardization sample is stratified to ensure it is representative of the 1990 US Census. Dates of publication for the WAIS and WAIS-R were 1955, 1981 and 1997, respectively.

The subtests of the WAIS, WAIS-R and WAIS-III are highly reliable (average reliability range from 0.77 to 0.96 for the Verbal tests and from 0.68 to 0.90 for the Performance tests). Standard errors of the intercorrelations are small, on the order of 0.05. The sample sizes are adequate. Thus, no corrections were made for unreliability.

Ten subtests are common to each version of the WAIS. For consistency, only these subtests were used in the present study. For each of the tests, correlations between individual subtests were normalized using Fisher transformations. The means of these transformed correlations were then compared across:

- All 55 correlations between subtests.
- The 15 Verbal subscales.
- The 10 Performance subscales.
- The 30 correlations between the Verbal and Performance scales.

Post-hoc comparisons were then made using *t*-tests at the 0.05 α level. Because a decline in test correlations was predicted, all tests for significance were one-tailed. These analyses were then followed by maximum likelihood analysis to compare the correlation matrices for equality.

3. Results

Mean intercorrelations are presented in Table 1. As can be easily noted, each group of correlations exhibited a decline in the predicted direction, indicating a diminishing role of Spearman's *g* for each version of the WAIS. Row 1 reports that, when all subtests are considered, the mean intercorrelations decrease from 0.65 in the WAIS to 0.57 in the WAIS-R and finally to 0.54 in the WAIS-III. For the Verbal subtests, found in row 2, intercorrelations were stable across the WAIS, WAIS-R and WAIS-III. No significant change was noted. In terms of magnitude, the largest decrease occurred among the intercorrelations between the Performance subtests, found in row 3. The mean intercorrelations decreased from 0.64 to 0.50, a drop of 0.14. This difference is significant at the 0.01 α level. As judged by the *F* statistic, the most significant decline occurred among the intercorrelations between the Verbal and

Table 1
Mean correlations between subtests in the WAIS, WAIS-R and WAIS-III^a

Tests	WAIS		WAIS-R		WAIS-III		<i>F</i>
	Mean	S.D.	Mean	S.D.	Mean	S.D.	
All	0.65a	0.14	0.57b	0.15	0.54b	0.16	7.30**
Verbal	0.77a	0.19	0.72a	0.18	0.70a	0.21	0.38
Performance	0.64a	0.07	0.52b	0.10	0.50b	0.11	6.30**
Verbal–Performance	0.59a	0.08	0.50b	0.07	0.47b	0.08	17.80**

^a**Denotes statistical significance using one-tail tests at the 0.01 α level. Means in the same row which do not share subscripts differ at $p < 0.05$, using the Tukeys honestly significant difference comparison.

Performance scales. Row 4 reports that values declined from 0.59 for the WAIS to 0.50 for the WAIS-R and ultimately to 0.47 for the WAIS-III, a drop significant at the 0.0001 α level.

Pairwise comparisons are also presented in Table 1. When all subtest intercorrelations are considered (row 1), a significant difference was noted between the WAIS and WAIS-R, as well as the WAIS and WAIS-III. A similar pattern was identified with Performance scale and the Verbal–Performance intercorrelations (rows 3 and 4). That is, significant differences exist between the WAIS and WAIS-R, as well as the WAIS and WAIS-III. Pairwise comparisons found no significant difference among the Verbal scale intercorrelations, however (row 2). No significant differences were observed between the WAIS-R and WAIS-III, regardless of intercorrelation group.

Maximum likelihood analysis substantiated the results of the ANOVAs performed across the groups of transformed correlations. When correlation matrices from the WAIS, WAIS-R and WAIS-III were tested for equality, the resulting χ^2 was 1584.45, with 132 degrees of freedom. These results indicate there are significant differences between the correlation matrices.

4. Discussion

Spearman's law of diminishing returns posits that intelligence tests have lower intercorrelations among high ability groups than among low. From this observation it follows that the increase in intelligence that has occurred over the past years should likewise evidence an accompanying decrease in intercorrelations between tests. Examination of the WAIS, WAIS-R and WAIS-III shows the predicted decline has indeed taken place over a 42-year period, between 1955 and 1997. While all subtests were affected to some extent, significant declines occurred among the Performance and Verbal–Performance subtest intercorrelations. In his massive survey of cognitive abilities, Carroll (1993) equated the WAIS Performance subtests to be measures of a visualization or spatial abilities (G_s). The Verbal subtests were taken to be approximations of crystallized abilities (G_c). Therefore, the findings of this study suggest that the factors responsible for the Flynn effect have their greatest impact on visualization and spatial abilities, resulting in lower intercorrelations among the subtests comprising these cognitive abilities. From the post hoc analysis, a further conclusion may be drawn that the

Flynn effect exerted its greatest influence between 1955 and 1981, the standardization dates of the WAIS and WAIS-R, respectively. During the 16-year period between the WAIS-R and WAIS-III standardizations, no significant decrease in correlations was observed. Thus, the Flynn effect has ‘decelerated’ in recent years, resulting in a leveling off in the secular decline of Spearman’s *g*.

Among the possible explanations for the observed pattern of correlations, four stand out. The first explanation is that high ability individuals inherently possess cognitive abilities which are more specialized and distinct than those of low ability individuals. Anderson (1992) offers a variant of this account, explaining that the overall performance of high-IQ individuals permits specific cognitive abilities to be reliably distinguished in much the same way as a superior radio or tape recorder allows the listener to distinguish and isolate the nuances of music. This explanation may help account for the oft-noted varied performance of high-IQ individuals on standardized intelligence tests. The second explanation is that social and educational factors permit greater differentiation of cognitive abilities. It may be that children and adults who are considered bright are encouraged to excel in specialized activities, such as chess, writing and computers. The development of one or two unique talents may nurture the development of specialized abilities over time. For example, Flynn (1987, 1998) has noted that the most dramatic increases in measured IQ has been on nonverbal, visual-spatial tests, such as Ravens Progressive Matrices. Therefore, lower test intercorrelations may not reflect a diminishment in the importance of *g* per se, but rather the improvement of specific primary cognitive abilities. The third explanation is that our society has become sufficiently complex over time as to demand the specialization of cognitive processes. For example, the demands of schooling may act as catalysts for the differentiation of cognitive abilities Ceci (1990). The fourth explanation is that smarter people use fewer intellectual resources in the solution of problems. If fewer intellectual resources are deployed in problem solution, there would naturally be lower test intercorrelations. In recent years, studies have found that neural efficiency is significantly related to cognitive ability (Vernon, 1993). Further evidence along these lines may be found in studies of reaction time (RT). Most investigations (e.g. Kranzler, 1994) utilizing RT in the study of intelligence find a negative relationship between the speed and efficiency of information processing and psychometric intelligence. In any case, as abilities become specialized and differentiated, the intercorrelations would naturally decrease. The conclusion to be drawn is that there has been a secular decline in Spearman’s *g*. This study further confirms the law of diminishing returns as an influence over populations and time, not restricted to groups at any one point in time.

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