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***Title page with author details**

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The unitary ability of IQ in the WISC-IV and it's computation

Abstract

Flanagan e Kaufman (2009) use a difference of 23 IQ points between the highest score (Max) and the lowest score (Min) reported by subjects in the 4 Indexes of Verbal Comprehension, Perceptual Reasoning, Working Memory and Processing Speed to define unitarity of IQ in the WISC-IV. Such a difference in scores is considered very rare and the authors therefore conclude that the total IQ scores in these cases cannot be interpreted. Hereby, we want to argue against the choice of this cut-off threshold value by showing that it was based on the wrong standard deviation value when first computed.

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Highlights

1) We present a method to compute the threshold for non-interpretability of WISC-IV IQ

2) We estimated means and sds of differences Max-Min between the 4 Indexes of WISC-IV

3) We computed the % of participants who obtain certain Max-Min differences on WISC-IV

The unitary ability of IQ in the WISC-IV and it's computation

Introduction

Flanagan e Kaufman (2009, p. 143) define unitary ability as "an ability (...) that is represented by a cohesive set of scaled scores, each reflecting slightly different or unique aspects of the ability". The authors then use the difference between the highest score (Max) and the Lowest score (Min) obtained by a participant in the four Indexes of the test: Verbal Comprehension (VCI), Perceptual Reasoning Index (PRI), Working Memory Index (WMI) and Processing Speed Index (PSI), to determine the unitary ability of the IQ in the WISC-IV (Wechsler, 2003a,b). For Instance, if a participant's scores were VCI= 120, PRI= 110, WMI= 125 and PSI= 115, his Max-Min difference would be the difference between the highest value of the four Indexes (WMI= 125) and the lowest (PRI= 110), that is 125-110= 15. If this difference is large and infrequent, then the IQ is considered non interpretable. Therefore an IQ score is declared non interpretable if the Max-Min difference between the four indexes is larger than a certain threshold or cut-off value which is computed according to the formula 1.5*SD where 1.5 is the z score that corresponds to the desired area under the normal curve distribution (about 6.7% of a tail) and 15 is the value used for SD, that is the standard deviation of standard scores (Mean = 100 and SD =15). The threshold value that is therefore obtained is 22.5 which is then rounded up to 23. The authors expect this formula to be valid for any Wechsler scale and for any standardization sample regardless of country of origin of the sample.

However, Flanagan and Kaufman (2009) don't give any information with regards to the percentage of participants in the WISC-IV USA standardization sample who score up to and above this cut-off point. This information is nevertheless very important for clinicians who are otherwise left without any means of assessing the incidence of this threshold on the population towards which the test is set, because the data regarding the distribution of the Max-Min differences in the sample are not published.

During the standardization process of the WISC-IV for the Italian population (Wechsler, 2012; Orsini, Pezzuti, Picone, 2012; Orsini, Pezzuti, 2014) we found that as much as 51.6% of participants in the standardization sample had a Max-Min difference score equal or greater than 23. It is therefore even more important to know the equivalent percentage firstly observed in the USA sample.

Our present aim is that of estimating this percentage value in the USA standardization sample of the WISC-IV and of comparing it with that of the Italian standardization sample.

Methodology

Sample and instruments

The data published in the Technical and Interpretive Manual of the WISC-IV (Wechsler, 2003b) are used for all the computations involving the USA sample while those involving the Italian sample are based on its standardization sample (Wechsler, 2012; Orsini, Pezzuti, Picone, 2012; Orsini, Pezzuti, 2014). The Italian standardization sample comprises 2200 participants (1100 females and 1100 males) divided into 11 age groups from 6 years old to 16 years old. Each age group therefore comprises 200 participants (100 females and 100 males). The sample is representative of the Italian population according to level of parental education.

Statistical Analyses

As already noted by Silverstein (1987, p. 410) "If x_1 and x_2 are the lowest (Min) and the highest (Max) values, respectively, in a sample of n independent observations, the range of the sample in standardized form is $W = (x_n - x_1)/\sigma$, where σ is the standard deviation of X.".

Additionally, as suggested by Miller (1981, p.46), it is possible to correct for situations were individual scores are correlated by multiplying the denominator by $\sqrt{1-\rho}$. Then the scaled-score range of the 100P% of the standardizatin sample will be estimated by computing the product of the critical value at the 1-P probability level (Owen, 1962, Table 6.1) and $15\sqrt{1-\rho}$ given that for the Indexes of the WISC-IV $\sigma = 15$ and ρ is given by the average intercorrelation among the Indexes. The product of E(W) and $\sqrt{\sigma^2(W)}$ (Owen, 1962, Table 6.2) respectively, by the same value will then provide and estimation of the mean and standard deviation for the scaled score range.

The two analyses that follow aim at first, estimating the Max-Min values associated with different percentages of occurrence in both the USA and Italian standardization sample and, second, at estimating the mean and standard deviation of the Max-Min differences both the USA and the Italian standardization sample. When dealing with the Italian standardization sample, we will also be able to present the empirical data for both statistical analyses.

1) In order to estimate the Max-Min values associated with various percentages of frequency we will use formula [2] as suggested by Silverstein (1989):

$$\mathbf{R} = \mathbf{q} \cdot \sigma\sqrt{1 - 2\sum \mathbf{r}_{ij} / \mathbf{k}(\mathbf{k}-1)}$$

Where q is the critical value of the studentized range (for $\alpha = 0.01 - 0.05 - 0.10 - 0.20 - 0.30 - 0.40 - 0.50 - 0.60 - 0.70 - 0.80 - 0.90$); k is the number of Indexes (4) used to compute the Max-Min differences on which the unitary ability and the interpretability of the IQ are based; and R is the threshold Max-Min value up to and above which the sample scores according also to the α levels used. The values of q for each α value are taken from the tables provided by Harter & Balakrishnan (1998) with 4 and ∞ df. The common standard deviation is 15 and the intercorrelations r are provided in Table A.1 of Wechsler (2003b) for the USA sample and in Table 3-12 of Orsini, Pezzuti, Picone (2012) for the Italian sample.

2) In order to estimate the mean and the standard deviation and the Max-Min differences we will use the method already used by Silverstein (1987, 1988) and described by Owen (1962) which computes the product of $15\sqrt{1-\rho}$ (where 15 is the standard deviation of the Indexes and ρ is the average correlation between the Indexes) by E(W) and $\sqrt{\sigma^2(W)}$ (Owen, 1962, Table, 6.2).

Results

Table 1 shows R values, that is Max-Min differences for the USA sample and the Italian sample, for each α level. For the Italian sample we also show the empirical values of such distribution (Orsini, Pezzuti, 2014).

According to Table 1, using the threshold suggested by Flanagan e Kaufman (2009), more than 40% of the participants in the USA standardization sample and more than 50% in the Italian standardization sample score above the cut-off point of 23 and would therefore be considered as having a non-interpretable IQ according to Flanagan and Kaufman.

INSERT TABLE 1 ABOUT HERE

Table 2 shows the Means and SDs of the estimated Max-Min differences between the four Indexes of the WISC-IV together with the empirical values of the Italian standardization (Orsini, Pezzuti, 2014). It is then possible to estimate the percentage of participants who score up to and above the threshold of 23 points suggested by Flanagan and Kaufman by transforming this score in a z score using the Mean and SD estimated for the USA sample $z = (23 - 21.6)/9.2 = 0.15$. The corresponding percentage of participants who score up to and above this z score can then be obtained from the tables of the normal distribution, which in this case is 44% of the population.

INSERT TABLE 2 ABOUT HERE

Conclusions

If the main criterion for defining the non interpretability of the IQ is based on the relative infrequency of the Max-Min difference, it seems clear that the method used by Flanagan and Kaufman (2009) isn't really fit for purpose. It is our opinion that, looking at the formula 1.5*SD, the problem does not rest in the z score of 1.5, which can be altered according to the percentage of cases that one needs to isolate, but rather with the specific standard deviation that has been chosen. Flanagan and Kaufman used a standard deviation of 15, which is the one of the standard scores (mean =100 and SD = 15), that is the standard deviation of the IQ distribution or of the individual Indexes scores. However, we are here dealing with the distribution of the Max-Min differences between the four Indexes. We therefore think that it would be more appropriate to use the standard deviation of such a distribution. Moreover, one can observe that using the estimated mean and standard deviation of the USA standardization sample as much as 44% of the USA sample would result as having a non interpretable IQ. This value would be even higher for the Italian population, in which we know as much as 51.6% of the standardization sample scores up to or above the cut off point of 23 points in the Max-Min difference of the Indexes. This value is very close to the one obtained using Silverstein's (1989) method. While we wait for the data relative to the USA standardization sample, it is in the meanwhile possible to compute which threshold would isolate only 10% of the USA sample by choosing a $z = 1.28$ and our estimated mean and standard deviation for the Max-Min differences distribution: $M + z*SD = 21.6 + 1.28*9.2 = 33.4$. By varying the z score that we choose, it is possible to include a higher percentage of participants. So by choosing $z = 1.13$, for instance, we would obtain a threshold score of 32 points difference which 13% of the population reaches. This way the clinician will be able to choose the more appropriate threshold in order to define the unitary ability of the IQ while, however, still meeting the necessary criterion of relative infrequency.

All that we have argued so far can be also extended and applied to the concept of unitary ability of the Indexes, where the Max-Min difference which we would consider is, in that case, the one between the various subtests included in each individual Index. Here again, according to Flanagan and Kaufman, the threshold should be computed according to 1.5*SD, where SD (=3) is the standard deviation of the weighted scores of the individual subtests and here again one would need to substitute this SD value with the standard deviation of the Max-Min differences between the specific subtests that go to constitute each Index. The formula to use in the computation of the threshold, for both the IQ and the Indexes, is: $M + z*SD$, where M and SD are the mean and the standard deviation of the Max-Min differences. While we wait for the data of the USA standardization sample to be published, the thresholds could be computed using our method.

It is immediately clear how the use of a correct threshold value as opposed to the one suggested by Flanagan and Kaufman has an immediate effect on both the individual diagnostic as well as on the study of clinical groups. An example of this could be found in the work of Liratni e Pry (2007) who tested a sample of 20 gifted children (IQ>130) aged 9 years and 10 months to 12 years and 10 months with the WISC-IV. The authors encounter a non interpretability in 18 of the 20 participants. In a subsequent study the same authors (Liratni e Pry, 2012), still using a threshold of 23 points difference, found that the IQ is non interpretable for 87% of gifted children and they continue drawing general theoretical conclusions about the relevance of the g factor.

References

Flanagan, D. P., Kaufman, A. S. (2009). *Essentials of WISC-IV Assessment*. Second Edition. John Wiley & Sons. Hoboken. New Jersey.

Harter, H. L., Balakrishnan, N. (1998). *Tables for the Use of Range and Studentized Range in Tests of Hypotheses*. CRC Press. Boca Raton. New York

Liratni, M., Pry, R. (2007). Psychometrie et WISC-IV: quel avenir pour l'identification des enfants à haut potentiel intellectuel? *Neuropsychiatrie de l'Enfance et de l'Adolescence, 55,* 214-219.

Liratni, M., Pry, R. (2012). Profils psicométriques de 60 enfants à haut potentiel au WISC-IV. *Pratiques Psychologiques, 18,* 63-74.

Orsini, A., Pezzuti, L. (2014, *in press*). *Dalla WISC-III alla WISC-IV*. Giunti OS. Firenze.

Orsini, A., Pezzuti, L., Picone, L. (2012). *WISC-IV. Contributo alla taratura italiana.* Giunti-OS. Firenze.

Owen, D. B. (1962). *Handbook of statistical tables,* Reading. MA. Addison-Wesley.

Silverstein, A. B. (1987). Two indices of subtest scatter on Wechsler's intelligence scales: estimated vs. empirical values. *Journal of Clinical Psychology, 43,* 409-414.

Silverstein, A. B. (1988). Estimated vs. empirical values of scaled score range on Wechsler's intelligence scales: a correction. *Journal of Clinical Psychology, 44,* 259-260.

Silverstein, A. B. (1989). Reliability and Abnormality of Scaled-Score Ranger. *Journal of Clinical Psychology, 45,* 926-929.

Wechsler, D. (2003a). *Wechsler Intelligence Scale for Children-Fourth Edition (WISC-IV) Administration and Scoring Manual.* San Antonio, TX: The Psychological Corporation.

Wechsler, D. (2003b). *Wechsler Intelligence Scale for Children-Fourth Edition (WISC-IV) technical and interpretive manual.* San Antonio: The Psychological Corporation.

Wechsler, D. (2012). *WISC-IV. Wechsler Intelligence Scale for Children Quarta Edizione*. Giunti-OS. Firenze.

Table(s)

Table 1 - Risultati della formula [2] di Silverstein (1989) applicata ai dati del campione statunitense e del campione italiano della WISC-IV

		R		
α	$Q_{4,\infty}$	USA (est)	ITALY (est)	ITALY (emp)
0,01	4,403	46,2	51,5	52
0,05	3,633	38,1	42,5	42
0,10	3,240	34,0	37,9	40
0,20	2,784	29,2	32,6	33
0,30	2,469	25,9	28,9	29
0,40	2,210	23,2	25,9	26
0,50	1,978	20,8	23,1	23
0,60	1,757	18,4	20,6	21
0,70	1,531	16,1	17,9	18
0.80	1,286	13,5	15,0	15
0,90	0,979	10,3	11,5	11

Table 2 - Medie e ds delle differenze stimate Max-Min dei 4 Indici della WISC-IV applicata ai dati del campione statunitense e del campione italiano della WISC-IV

	USA (est)	ITALY (est)	ITALY (emp)
Mean	21.6	24.1	24.0
SD	9.2	10.3	10.5