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Prevalence of low scores and discrepancy of results on intelligence measure (WAIS-IV) in adults

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Abstract: Wechsler Adult Intelligence Scale is one of the world's most recognizable measures of intelligence for adults, comprised of 10 core and 5 supplemental subtests. Since it is a battery of tests, research of discrepancy between subtest scores enables conclusions regarding possible misinterpretations of a single test score. Adaptation and standardization of the fourth revision of WAIS was conducted in 2019. for Croatian language.
The aim of the study was to examine the prevalence of low scores on subtests and Indexes as well as the difference between scores regarding overall intelligence level.
Data was gathered for 700 adults (343 males and 357 females), aged between 16 and 74 years. The sample was stratified according to age, self-reported gender (male/female), and five geographical regions.
The results show that single low scores among healthy adults are not uncommon, even when using strict and rigorous cut-off scores such as below 2nd percentile (i. e. 12.9 for subtests and 5.7 for Index scores). Also, results show that 1 out of 4 participants of the study had differences between Index scores greater than one standard deviation, and those differences were greater and more common in groups with above average and high overall intelligence. These results indicate that variability of results is a normal feature of cognitive functioning and should not automatically be considered as proof of existence of a cognitive disorder.

Keywords: discrepancy of results, intelligence, WAIS-IV-HR, subtests, index scores

Introduction

Psychologists have been trained to interpret performance on cognitive tests based on the bell curve, but studies have shown that this can result in a misinterpretation of low scores because it is common for healthy individuals to have a variability in their cognitive abilities (Brooks, Iverson, Holdnack, 2013).

The clinical inference derived from a percentile rank is a relatively accurate indicator of a person's level of functioning on each test in *isolation*, but not when all tests are considered *simultaneously* (Brooks, Iverson, Holdnack, 2013). The probability of obtaining a score at or below the 5th percentile is 5%, but this percentage is much higher when considering the entire battery (Brooks, 2010). Understanding the prevalence of low scores when multiple tests or test batteries are used can improve diagnostic accuracy and clinical usefulness of the tests, as it gives us an estimate of probability that a specific obtained result is clinically significant and unusual in the normative population (Matešić, Ružić, Štefanec, 2020).

For example, research on Wechsler Adult Intelligence Scale – Fourth Edition (WAIS-IV; Wechsler, 2008) shows that only 0.3% of healthy adults have all subtest scores in spread of one standard deviation (difference between highest and lowest score). Summarizing and interpreting a large amount of test information is an evolving skill set for clinicians so Brooks, Iverson and Holdnack (2013) list five principles for understanding and interpreting multivariate base rates:

1. Low scores are common across all batteries of cognitive tests
2. The number of low scores depends on where you set your cut-off score (there is an inverse relation between the number of low scores and the cut-off score used)
3. The number of low scores depends on the number of tests administered and interpreted
4. The number of low scores vary by demographic groups
5. Ability level (e.g., intelligence) impacts the rate of obtained low scores.

Base rate analyses can at times be very helpful for a better understanding of how common or uncommon it is to get certain patterns of low scores. As Brooks, Iverson and Holdnack (2013) note, it would be a serious mistake to interpret cognitive tests in isolation but “practitioners rely heavily on the immutable characteristics of the bell curve and often unwittingly apply the logic of a single test score to a battery of tests” (pp 89).

Research on different test batteries has been done in different countries (e.g. Brooks, 2011; Grégoire, Coalson, Jianjun, 2011; Matešić, Ružić, Štefanec, 2020), as well as review papers on different batteries (e.g. Binder, Iverson, Brooks, 2009). Caution warnings against over-interpreting isolated low scores have been present in the literature for over 30 years; in 80-is researchers emphasized the extent of normal variability in test results and distinction between statistically significant and clinically significant results (e.g. Matarazzo and Herman, 1984; Matarazzo and Prifitera, 1989). Ingraham and Aiken (1996) report that in a battery of only six tests, using a cut-off of 1 *SD* below average, more than 20% of the normative samples would be classified as having abnormal performance on at least two measures. Later research (e.g. Crawford, Garthwaite, Gault, 2007) showed that in such estimations one should consider the intercorrelations between measures in a battery, as when using Monte Carlo simulation, which appear to predict the number of low scores roughly consistent with base rates (Binder, Iverson, Brooks, 2009). Binder, Iverson and Brooks (2009) note that statistical methods are very useful when data about base rates is not available, but also that it is extremely important to have actual base rates on different neuropsychological batteries and in different countries reported.

The aim of this study was to examine the variability of test scores, as well as prevalence of low scores and base rates on the WAIS-IV-HR in the Croatian standardization sample.

Method

Participants

Study included a sample of 700 adults, aged between 16 and 74 years, i.e. Croatian normative sample for standardization of WAIS-IV-HR (343 males and 357 females).

The sample was stratified according to age, self-reported sex (male/female), and five geographical regions, based on the 2011 Census of the Republic of Croatia (Croatian Bureau of Statistics, 2013; no newer data was available at the time of the study). Exclusion criteria for the participation were impairment of vision or hearing that had not been treated, insufficient knowledge of the Croatian language, disability of the upper extremities, history of major psychiatric disorders, learning disorders or brain injury.

Procedure

Participation in the study was voluntary, and participants were free to terminate the participation at any moment. All participants signed the informed consent and for those under the age of 18 parental informed consent was granted.

Testing was done by graduate psychologists with experience in the application of psychodiagnostic tests. The test was administered individually and lasted for approximately two hours for each participant. Administration of all subtests was conducted by the directions given in the test Manual (Wechsler, 2019). Participants had the possibility of obtaining their results after the completion of the research.

Measure

Wechsler adult intelligence scale–IV–HR (WAIS-IV-HR; Wechsler, 2019) consists of 10 core and 5 supplemental subtests that are combined on four Index scores and Full Scale IQ score (Table 1). Raw scores for each subtest are converted to a scaled score ($M=10$, $SD=3$). Scores on core subtests are combined in Index scores and Full Scale IQ ($M=100$, $SD=15$). Prevalence of low scores in the overall sample is extracted, as well as prevalence for different levels of intelligence of examinees.

Results

Using cut-off scores of 25th, 16th, 9th, 5th and 2nd percentile, prevalence of low scores on sub-

Table 1. Core and supplemental subtests and Index scores of WAIS-IV

	Verbal Comprehension Index	Perceptual Reasoning Index	Working Memory Index	Processing Speed Index
Core subtests	Similarities	Block Design	Digit Span	Symbol Search
	Vocabulary	Matrix Reasoning	Arithmetic	Coding
	Information	Visual Puzzles		
Supplemental subtests	Comprehension	Figure Weights*	Letter-Number Sequencing*	Cancellation*
		Picture Completion		

Note. Supplemental subtests marked with asterisk are for ages 16 to 69 (not older).

Table 2. Prevalence of low subtests and index scores on WAIS-IV-HR

Number of low subtest scores	≤ 25. percentile	≤ 16. percentile	≤ 9. percentile	≤ 5. percentile	≤ 2. percentile
10	2.9	0.7	0.3	-	-
9 or more	4.7	2.0	1.0	0.1	-
8 or more	7.9	3.4	1.3	0.2	-
7 or more	11.0	6.1	2.7	0.8	-
6 or more	17.6	9.1	3.9	1.0	-
5 or more	24.0	13.6	5.4	1.5	0.4
4 or more	32.6	18.6	9.6	2.7	0.7
3 or more	43.4	27.4	14.6	5.4	1.4
2 or more	62.6	41.9	23.4	10.8	4.3
1 or more	80.0	65.0	42.9	23.4	12.9
No low scores	20.0	35.0	57.1	76.6	87.1
Number of low Index scores	**≤ 25. percentile**	**≤ 16. percentile**	**≤ 9. percentile**	**≤ 5. percentile**	**≤ 2. percentile**
4	6.7	3.0	1.6	0.9	-
3 or more	15.6	7.7	3.9	1.9	0.6
2 or more	28.1	16.6	9.7	5.6	1.7
1 or more	54.3	34.9	22.1	12.7	5.7
No low scores	45.7	65.1	77.9	87.3	94.3

tests of WAIS-IV was analyzed (Table 2). When using a value of one standard deviation below average (16%) in analyzing subtest scores, only 35% of adults had no low scores, meaning that 65% of the sample had one, and more than 40% had two or more low scores. Percentage of low scores is, of course, lower with the use of more strict cut-off scores, but still when using 5th percentile as a cut-off, more than 20% of adults had one or more low scores. Even when using a measure of two standard deviations below average (2nd percentile), the percentage of adults having one or more low subtests score was almost 13%, and having one or more low Index scores was more than 5% (Table 2).

Analysis of differences between scaled scores (M=10, SD=3) on 10 core subtests of WAIS showed that 75.1% of participants had a discrepancy of 6 or more scores (i.e. difference of 2 SD), while 21.3% had discrepancy of 9 or more scores (i.e. difference of 3 SD) between the lowest and highest scaled score on subtests. Only 0.1% of the sample had differences below 3 scaled scores (i.e. within 1 SD).

When the sample is divided by the overall FSIQ result, the likelihood of having a large difference between test scores is smaller among groups with below average FSIQ (Table 3).

Table 3. Prevalence of differences between scaled scores of subtests on WAIS-IV-HR by the result on Full Scale IQ (FSIQ)

Difference between scaled scores on 10 core subtests	FSIQ extremely low (<80)[a]	FSIQ low average (80-89)[b]	FSIQ average (90-109)[c]	FSIQ high average (110-119)[d]	FSIQ superior (120+)[e]
12 or more	-	-	2.0	3.3	1.4
11 or more	-	-	4.2	10.6	5.4
10 or more	-	4.4	11.2	24.4	14.9
9 or more	3.7	11.0	21.8	31.7	27.0
8 or more	11.1	17.6	36.6	41.5	50.0
7 or more	25.9	39.6	59.5	57.7	66.2
6 or more	50.0	65.9	80.2	74.0	82.4

Note. [a]*N*=54; [b]*N*=91; [c]*N*=358; [d]*N*=123; [e]*N*=74.

Table 4. Prevalence of differences between scaled scores of subtests within each Index of WAIS-IV-HR

Difference between scaled scores	VCI 3 subtests	PRI 3 subtests	WMI 2 subtests	PSI 2 subtests
12 or more	-	0.1	-	
11 or more	-	0.3	-	
10 or more	0.4	0.7	-	0.1
9 or more	0.6	1.3	-	0.4
8 or more	1.9	2.9	1.3	0.7
7 or more	4.4	6.9	2.9	1.9
6 or more	9.1	13.1	6.3	4.4
5 or more	20.1	26.1	12.4	9.4
4 or more	29.7	42.3	22.4	17.0
3 or more	60.3	66.1	38.7	30.3

Note. VCI = Verbal Comprehension Index; PRI = Perceptual Reasoning Index; WMI = Working Memory Index; PSI = Processing Speed Index.

Differences between scaled scores within each Index that consist of 2 or 3 subtests (with results on standardized scale with M = 100, SD = 15), were also analyzed (Table 4). Results show that around 60% of the sample have a difference greater than 1 *SD* (3 points) in indices containing three subtests but that percentage was lower for indices containing only two subtests.

Results show that overall, around 75% of healthy adults in the sample had differences between Index scores greater than one standard deviation, and 20% of the sample had differences greater than two standard deviations.

Table 5. Prevalence of differences between Index scores on WAIS-IV-HR

Difference between Index scores	FSIQ extremely low (<80)[a]	FSIQ low average (80-89)[b]	FSIQ average (90-109)[c]	FSIQ high average (110-119)[d]	FSIQ superior (120+)[e]
45 or more	-	1.1	3.1	5.7	4.1
40 or more	-	4.4	4.7	7.3	9.5
35 or more	1.9	11.0	11.7	17.9	14.9
30 or more	7.4	13.2	19.8	26.8	27.0
25 or more	22.2	26.4	35.2	37.4	48.6
20 or more	40.7	48.4	54.5	53.7	67.6
15 or more	61.1	65.9	77.4	74.8	81.1

Note. [a]*N*=54; [b]*N*=91; [c]*N*=358; [d]*N*=123; [e]*N*=74.

In order to check the prevalence of differences of one *SD* (i.e. 15 points) or more between indexes depending on the overall IQ level, sample was divided by FSIQ level and results are shown in Table 5. Differences larger than 2 *SD* are more common in groups with high average and superior FSIQ (more than 25% of healthy adults). This indicates that 1 out of 4 adults with high average FSIQ has at least one score on the Index that is 2 *SD* below others. It should be noted that the WAIS-IV test manual indicates that in cases of discrepancies larger than 1.5 *SD* between two Indexes FSIQ should not be interpreted.

Discussion

The aim of this study was to provide base rates of low scores on 10 core subtests and four Indexes of the WAIS-IV-HR in the Croatian standardization sample. Results show that the prevalence of low scores on subtests among healthy adults is not small, even when using strict and rigorous cut-off scores such as below 2nd percentile (the prevalence is more than 10%). When using 5th percentile as cut-off score, the prevalence of one or more low scores is more than 20%, which shows that by treating batteries the same way as single tests increases the likelihood of misdiagnosing results as clinically significant. The percentage is somewhat lower (around 5%) when using Index scores, suggesting that those are more reliable measures than single subtests itself. These results are in line with other research on Wechsler Adult Intelligence Scales (e.g. Brooks et al., 2008) but also with research on other batteries of tests (e.g. NEPSY-II, Brooks, Sherman, Iverson, 2010; Neuropsychological Assessment Battery – NAB, Stern & White, 2003; the Expanded Halstead-Reitan Neuropsychological Battery - E-HRNB, Heaton et al., 2004).

Converting raw scores on normative scores such as scaled scores or Index scores on WAIS-IV enables a comparison between the lowest and highest score in the battery. Overall, almost all the participants in this study (99.9% of them) had a difference between scaled scores on 10 core subtests above 3 points (i.e. only 0.1 had difference within one *SD*). These results are in line with data presented for the American version of WAIS-

IV (0.3% of healthy adults; Wechsler, 2008). The likelihood of having a large difference between test scores was smaller among groups with extremely low and low average FSIQ. This result is in line with previous research on different revisions of Wechsler Adult Intelligence Scale - WAIS (i.e. WAIS-R, WAIS-III as well as WAIS-IV; Binder et al.,2009).

When considering the 10 core subtests more than 2/3 of the sample had two standard deviations discrepancy between lowest and highest subtest score and almost 1/3 of the sample had discrepancy of 3 *SD* (9 or more points). When only subtests within specific Index were considered, such as three subtests of Verbal Comprehension or Perceptive Reasoning, or two subtests of Working Memory and Processing Speed, such big differences were not so common. Also, differences between Index scores were more common between individuals with high FSIQ values, indicating more variability in those groups. Results are in line with those of Grégoire Coalson and Jianjun (2011) that showed that variability in WAIS-IV composite score level is relatively frequent in the general population (more than 70% of individuals in the normative sample had at least one Index score that differs significantly from the mean index score). Although having one or more low scores on subtests or Indexes might not necessarily be an uncommon finding, that result can still reflect a relative weakness and point to some difficulties.

These results are consistent with contemporary hierarchical models of intelligence, such as the Cattell-Horn-Carroll (CHC) theory (Schneider & McGrew, 2012). Such models do not view general intelligence (or the g factor) as a single, homogeneous ability, but rather as a composite that arises from various broad and narrow cognitive domains – such as those measured by the WAIS-IV indexes. Within this framework, it is expected that the cognitive profiles of healthy individuals will reflect diversity (i.e. an individual may have average or even superior verbal abilities and at the same time his visual processing or working memory can be extremely low). The findings of present study that differences (discrepancies) between the indexes and subtests on the WAIS-IV-HR are not so uncommon provide empirical support for this viewpoint.

During past 30 and more years, researchers have emphasized the need for caution when interpreting multiple scores, especially to avoid type 1 errors (e.g. Naglieri and Paolitto, 2005), especially in clinical settings and the need for reporting base rates of low scores and score discrepancies in materials of the tests and batteries of tests. It is important to note that in this kind of base rate calculations, results reflect the prevalence in healthy adults, since individuals with mental problems or brain injuries are not included in the normative samples. Since, as Brooks (2010) state, not all subtests are equally sensitive for cognitive impairment and some clinical conditions are more sensitive to impairments in specific areas, further research is needed in clinical samples for the purpose of developing guidelines for identifying cognitive impairments in specific groups, based on psychometric data.

Binder, Iverson and Brooks (2009) note clinical implication of such results, indicating limits on the accuracy of the estimation of premorbid mental abilities using current cognitive test performance. Authors state that having a few scores significantly higher than others does not mean that the premorbid mental abilities were at the same level as the highest scores, which is a common conclusion in such testing. This marks the importance of research of prevalences of differences between results, such as present one, showing that conclusions made in praxis could be very misleading because of the prevalence of isolated high (or low) scores. This is especially important if we keep in mind that contemporary psychometric models of intelligence recognize that general intelligence is not a single, homogeneous ability, but rather a hierarchical composite of multiple distinct cognitive domains – such as those in the WAIS-IV: verbal comprehension, perceptual reasoning, working memory, and processing speed – with the overall IQ score serving as an aggregate index (Schneider & McGrew, 2012). It is important to remember that even in healthy individuals cognitive abilities are rarely equally developed, and caution is warranted when interpreting isolated low scores as indicative of pathology. Scores across domains can vary independently, meaning that individuals may show strengths in one area while performing more poorly in other areas. In other words, variability of results is a normal feature of cognitive functioning and should not automatically be considered as proof of the existence of a cognitive disorder.

Limitations of the study

This study was done on a normative Croatian sample, excluding individuals with known cognitive impairments, neurological disorders, or psychiatric diagnoses. Therefore, the generalization of these base rates to clinical populations should be used with caution. Future research should replicate these findings in specific clinical populations to validate their diagnostic accuracy and utility.

Conclusion

Analysis of the prevalence of low scores on WAIS-IV subtests and Indexes show that low scores are not as uncommon as would be expected based on bell curve and confirming that interpreting separate results of subtests on battery of tests can lead to misdiagnosis. The prevalence of low Index scores is smaller than on the subtest level but still should not be ignored. Also, practitioners should keep in mind that possible differences between Index scores are bigger in groups of people with higher intelligence levels, due to the overall range of results. As results show, variability in performance on different cognitive domains is a normal feature of cognitive functioning and low scores should not automatically be considered proof of a cognitive disorder.

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Prevalencija niskih rezultata i razlike među rezultatima na testu inteligencije (WAIS-IV) za odrasle

Sažetak: Wechslerov test inteligencije za odrasle jedan je od najpoznatijih testova inteligencije u svijetu, a sastoji se od 10 osnovnih i 5 dodatnih subtestova. Budući da se radi o bateriji, ispitivanje razlika među rezultatima na subtestovima omogućuje zaključivanje o mogućim pogrešnim tumačenjima pojedinačnih rezultata. Adaptacija i standardizacija četvrtog izdanja WAIS-a za hrvatski jezik provedena je 2019. godine.

Cilj istraživanja bio je ispitati prevalenciju niskih rezultata na subtestovima i indeksima, kao i razlika između rezultata, s obzirom na ukupnu razinu inteligencije sudionika.

Podaci su prikupljeni za 700 odraslih osoba (343 muškarca i 357 žena), u dobi od 16 do 74 godine. Ispitani uzorak je stratificiran prema dobi, spolu (muško/žensko) kako ga procjenjuje sam sudionik, te pet geografskih regija.

Rezultati pokazuju da postizanje niskih rezultata na pojedinačnim subtestovima nije neuobičajeno među zdravim odraslim osobama, čak niti ako se kao granični rezultat uzima stroga vrijednost, npr. ispod 2. centila (tj. vrijednost 12,9 za subtestove i 5,7 za indekse). Također, rezultati pokazuju da je razlika između postignuća na indeksima kod jednog od četiri sudionika bila veća od jedne standardne devijacije, pri čemu su razlike bile veće i češće u skupinama s iznadprosječnom i visokom inteligencijom. Ovi rezultati upućuju na to da je varijabilnost u postignućima na mjerama kognitivnog funkcioniranja uobičajena i da ju ne treba nužno smatrati pokazateljem postojanja kognitivnih teškoća.

Ključne riječi: razlike među rezultatima, inteligencija, WAIS-IV-HR, subtestovi, rezultati na indeksima

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