DOI: 10.26387/bpa.289.5

Advanced interpretation of WAIS-IV. The application of the CHC model to a WAIS-IV protocol

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ABSTRACT. Con la pubblicazione delle scale Wechsler di quarta generazione (WPPSI-IV, WISC-IV e WAIS-IV) avviene un cambiamento rilevante determinato dalle teorie differenti delle neuroscienze cognitive fondate sulla ricerca clinica e neuropsicologica. Dalle prime analisi fattoriali confermative condotte sui campioni di standardizzazione statunitense e italiano della WAIS-IV emerge la medesima struttura a quattro fattori. La WAIS-IV, in particolare, permette quindi il computo di quattro indici (o fattori): Comprensione verbale (ICV), Ragionamento visuo-percettivo (IRP), Memoria di lavoro (ML) e Velocità di elaborazione (IVE). Ciascuno degli indici concorre al computo del punteggio composito totale o Quoziente Intellettivo. Tuttavia, alla fine del secolo scorso sono comparsi numerosi modelli di intelligenza, alcuni dei quali hanno portano alla realizzazione di nuovi strumenti per la valutazione del costrutto o all'aggiornamento di quelli esistenti, e ricerche successive statunitensi e italiane hanno dimostrato che i dati della WAIS-IV possono anche essere letti alla luce della *Cattell*, *Horn*, *Carroll theory of intelligence* (o teoria CHC) distinguendo 5 fattori: Intelligenza cristallizzata (Gc); Elaborazione visiva (Gv); Intelligenza fluida (Gf); Memoria a breve termine (Gsm); Velocità di elaborazione (Gs). L'obiettivo del presente lavoro è quello di evidenziare attraverso un caso clinico l'utilità di avvalersi del modello a cinque fattori CHC invece di quello a quattro fattori, in particolare quando uno dei primi fattori risulta non interpretabile come abilità unitaria e coesa.

SUMMARY. A relevant change occurs with the publication of the fourth generation Wechsler Scales (WPPSI-IV, WISC-IV and WAIS-IV), determined by the different theories of cognitive neuroscience based on clinical and neuropsychological research. The first confirmatory factor analyses conducted on the US and Italian standardization samples of the WAIS-IV show the same four-factor structure. The WAIS-IV, in particular, allows the calculation of four indices (or factors): Verbal Comprehension Index (VCI), Perceptual Reasoning Index (PRI), Working Memory Index (WMI) and Processing Speed Index (PSI). Each of the indices contributes to the total composite score or Intellectual Quotient. However, at the end of the last century, numerous models of intelligence appeared, some of which led to the creation of new tools for assessing the construct or updating existing ones, and subsequent U.S. and Italian research have shown that the WAIS-IV data can also be read in the light of the Cattell, Horn, Carroll theory of intelligence (or CHC theory) distinguishing 5 factors: Crystallized Intelligence (Gc); Visual Processing (Gv); Fluid Intelligence (Gf); Short-Term Memory (Gsm); Processing Speed (Gs). The objective of this paper is to highlight through a clinical case the usefulness of using the five-factor CHC model instead of the four-factor model, particularly when one of the first factors is not interpretable as a unitary and cohesive ability.

Keywords: *WAIS-IV, CHC model, Clinical case*

INTRODUCTION

Numerous models of intelligence appeared at the end of the last century, some of which led to the development of new instruments for assessing the construct or updating existing ones. Since the tests most frequently used to measure cognitive abilities are built on the psychometric model (Neisser et al., 1996), we will focus our attention on the latest generation of psychometric models that have guided the implementation of the instruments and the reading of the results.

In the late 1990s, McGrew (1997) proposed a model that integrates the one proposed by Carroll (1993) and those proposed by Horn and Cattell.

Carroll cognitive abilities are differentiated into three layers (Strata) or levels. The architecture of the model is hierarchical and can be represented as a pyramid, at the apex of which is Stratum III, which is the conceptual equivalent of Spearman's and Vernon's g-factor. Stratum II is composed of a relatively small number of broad cognitive abilities (Fluid Intelligence, Crystallized Intelligence, General Memory and Learning, Visual Perception, Auditory Perception, Retrieval Ability, Cognitive Speediness, and Reaction Time). Beneath these broad skills, there are countless narrow skills (about 69) or abilities that are part of Stratum I.

Horn and Cattell's Gf-Gc model is a "truncated" hierarchical model, as it does not include a g-factor at the apex or a two-stratum model, in which first-order factors form the upper stratum and second-order factors form the lower stratum. The upper stratum includes several broad cognitive abilities; the lower stratum includes Thurstone's primary abilities (Horn, 1985) and the Cattell Horn Carroll theory of intelligence (CHC), a multicomponential hierarchical model with an unprecedented empirical basis (Schneider & McGrew, 2018).

The CHC model includes operationalized broad and narrow abilities: broad abilities are the basic constitutional characteristics of people that endure and can govern or influence a wide range of behaviours in a specific area, narrow abilities represent specific (detailed) aspects of the broad ability to which they belong). Broad abilities are: Crystallized Intelligence (Gc), Visual Processing (Gv), Quantitative Knowledge (Gq), Reading and Writing Ability (Grw), Short-Term Memory (Gsm), Fluid Intelligence (Gf), Processing Speed (Gs), Long-Term Storage and Retrieval (Glr), Auditory Processing (Ga), and Decision-Making Speed/Reaction Time (Gt). The narrow abilities underlying each broad ability are multiple.

Based on research data, the model has undergone some updates. In 2012 and 2018, Schneider and McGrew proposed significant revisions with the addition of new skills, the elimination of others, and a focus on the relationship between skills and information processing.

With the publication of the fourth-generation Wechsler Scales (WPPSI-IV, WISC-IV and WAIS-IV), a major change occurs in the history of this family of instruments, a change brought about by "different theories of cognitive neuroscience grounded in clinical and neuropsychological research" (Weiss, Saklofske, Coalson & Raiford, 2010, p. 62). In summary: the WPPSI-IV is an instrument for assessing cognitive functioning of subjects from 2 years, 6 months, and 0 days to 7 years, 3 months, and 30 days; the WISC-IV is an instrument for assessing cognitive functioning of subjects from 6 years, 0 months, and 0 days to 16 years, 11 months, and 30 days; the WAIS-IV is an instrument for assessing cognitive functioning of subjects from 16 years, 0 months, and 0 days to 89 years, 11 months, and 30 days.

From confirmatory factor analyses conducted on the U.S. (Wechsler, 2008) and Italian (Orsini & Pezzuti, 2013, 2015) standardization sample of the WAIS-IV, an important finding emerges: the same four-factor structure both considering only the 10 core subtests and all 15 subtests including the supplementary ones (the same result was found for the WISC-IV; Wechsler, 2003). The subtests are then grouped into four factors that assess specific cognitive domains. The WAIS-IV allows the calculation of four indices (factors): Verbal Comprehension Index (VCI), Perceptual Reasoning Index (PRI), Working Memory Index (WMI) and Processing Speed Index (PSI). Each of the indices contributes to the computation of the total composite score or Intellectual Quotient (IQ). To compute the four indexes, it is sufficient to administer the 10 core subtests.

The 5 supplementary subtests can be administered in two circumstances: 1) when the clinician needs to replace a core subtest with a subtest of the supplementary ones (for example, if a person has physical or sensory limitations, or if the score of a core subtest is invalidated because of errors in administration or because the person always answers "I don't know"); 2) there is a need for clinical investigation of a particular cognitive ability, and complete the diagnosis by analyzing discrepancies between different subtests.

The factorial structure of the WAIS-IV has been the subject of several analyses from which alternative models have emerged - in addition to the one formed by four factors - that allow a better understanding of the patient's "functioning".

The first factor analyses on the WAIS-IV data were conducted by Benson, Hulac and Kranzler (2010). Subsequently, Weiss, Keith, Zhu and Chen (2013) compared, based on U.S. data, both the four-factor and five-factor structures that best met Cattell, Horn, and Carroll's model (CHC; McGrew, 1997). The results of their analyses showed that:

– the Crystallized Intelligence factor (Gc) was saturated by the Similarity, Vocabulary, Information, and Comprehension subtests;
– the Visual Processing factor (Gv) was represented by the subtests Block Design, Matrix Reasoning, Puzzles, Figure Weights, and Picture Completion;
– the Fluid Intelligence factor (Gf) was saturated by the Matrix Reasoning, Figure Weights, and Arithmetic Reasoning subtests. Analyses also revealed a narrow ability in Quantitative Reasoning (QR), saturated by Figure Weights and Arithmetic Reasoning;
– the Short-Term Memory factor (Gsm) was represented by Digit Span, Letter and Number Sequencing and Arithmetic Reasoning;
– the Processing Speed factor (Gs) was represented by Coding, Symbol Search, and Cancellation.

These findings have been confirmed in more recent work such as that of Ryan and colleagues (Ryan, Kreiner, Gontkovsky, Golden & Myers-Fabian, 2019) and that conducted on the Italian calibration data of the WAIS-IV (Pezzuti, Lang, Rossetti & Michelotti, 2018).

Thus, the factorial structure of the WAIS-IV (in the US and Italian editions) allows us to read the results according to both the four-factor model (Wechsler, 2008; Orsini & Pezzuti, 2013, 2015) and the five-factor model or CHC model (Pezzuti et al., 2018; Weiss et al., 2013) for all age groups (16-90 years).

Regardless of the model chosen, the clinician can compute a total composite score (IQ) and some partial composite scores related to specific cognitive domains, which are particularly useful for understanding the subject's cognitive functioning (Kaufman, Raiford & Coalson, 2016; Weiss, Saklofske, Holdnack & Prifitera, 2016). On the other hand, if the clinician uses the CHC model, they must administer 15 subtests, which can be particularly burdensome for the patient. Hence the search for an alternative, which constitutes an "acceptable compromise" for both the patient and the clinician.

We therefore considered the hypothesis already explored by Lichtenberger and Kaufman in a 2009 paper: keeping the CHC theory as the reference theory and reducing the number of subtests to be administered to two subtests for each of the five CHC factors:

– Crystallized Intelligence (Gc): Vocabulary and Information;
– Visual Processing (Gv): Block Design and Puzzles;
– Fluid Intelligence (Gf): Matrix Reasoning and Figure Weights (supplemental subtest);
– Short-Term Memory (Gsm): Digit Span and Letter and Number Sequencing (additional subtest);
– Processing Speed (Gs): Symbol Search and Coding.

The choice of the pairs of subtests to be administered for each factor was guided by the results of Keith's (2009) confirmatory factor analysis and by the effects that the single broad ability measured by the clusters has in the clinic and, consequently, in the person's functioning in daily life.

In light of the considerations of Lichtenberger and Kaufman (2009) and the work of Pezzuti and colleagues (2018) to assess the broad ability of Crystallized Intelligence (Gc), we believe that the most appropriate subtests are Vocabulary and Information (core subtests), which have high levels of saturation across all age groups. The two subtests are excellent measures of the background knowledge possessed by a person and are less influenced by fluid reasoning than the other two subtests (Similarities and Comprehension) that contribute to the Verbal Comprehension Index (VCI) computation (Lichtenberger & Kaufman, 2009).

Block Design and Puzzles (core subtests) are the subtests that best appear to measure the broad Visual Processing (Gv) ability, as high saturations on the factor emerge for both age groups. The Picture Completion subtest, although it measures the broad Visual Processing skill (Gv), also requires Crystallized Intelligence (Gc) and the narrow skills of Flexibility of Closure (CF) and General Information (K0) for a correct performance and is therefore not very relevant to the broad skill.

The broad ability of Fluid Intelligence (Gf) can be measured by Matrix Reasoning (fundamental) and Figure Weights (supplemental), which have high saturations on the factor and strong representation of the construct (Flanagan, Ortiz & Alfonso, 2013; Lichtenberger & Kaufman, 2009). Figure Weights, moreover, as demonstrated in work on data from the Italian calibration of the WAIS-IV by Pezzuti and Rossetti (2017a, 2017b), can also be administered to older subjects.

The broad Short-Term Memory (Gsm) ability is measured by the fundamental Digit Span subtest and the supplementary Letter and Number Sequencing subtest, which are the subtests that most saturate the factor and represent it for both age groups. According to the results of the work of Pezzuti and Rossetti (2017a, 2017b), the Letter and Number Sequencing subtest can also be administered to Italian subjects over 69 (saturations on the Gsm factor are almost the same for both age groups considered). It is important for the psychologist to pay particular attention to Arithmetic Reasoning (core subtest) because, although it can be considered a measure of short-term memory, it also measures other broad abilities, such as crystallized knowledge, fluid reasoning and quantitative reasoning, as well as some other variables such as distractibility and anxiety (Lichtenberger & Kaufman, 2009).

To assess the broad ability of Processing Speed (Gs), the core subtests of Symbol Search and Coding, which are the same subtests that contribute to the Index of Processing Speed (PSI) [4-factor model in the U.S. and Italian manuals] appear to be adequate.

5-FACTOR CHC MODEL AND WAIS-IV

Having another model available (in addition to the 4-factor model) to interpret the WAIS-IV data, without this implying an excessive workload for the patient and the clinician, makes it possible to reduce the risk that the psychologist finds himself in the condition of not being able to explain the data obtained according to the "traditional" method of interpretation (4 factors), since one or more of these composite scores may sometimes not be unitary, namely internally cohesive. In fact, the clinician must keep in mind that when reading all composite scores (including the IQ reading), the unitary nature of the score must be considered. A composite score is unitary if the difference between the highest and lowest scores of its component values is less than a "threshold value" (Pezzuti, 2016). The "threshold value" corresponds to the minimum difference required, for a score to occur in a very low percentage (6.7%) of the general population. "Threshold values" for the Italian population are available in Orsini, Pezzuti and Hulbert (2015), Pezzuti (2016), and Lang, Michelotti, Bardelli and Pezzuti (in press).

For example, suppose that a 32-year-old patient obtains a total IQ of 119, to decide whether this IQ is representative of a unitary and internally cohesive ability, we need to analyse the difference between the highest and the lowest score among the 4 indexes that compose the total IQ. The same patient scored an VCI = 131, PRI = 121, WMI = 109 and PSI = 89, so we calculate the difference between the highest IQ (131 of VCI) and the lowest IQ (89 of PSI) which is 42 and compare it to the cut-off value which is ≥38, since 42 IQ points is higher than the cut-off we can reasonably conclude that the total IQ of 119 is not unitary and cohesive within it.

The lack of unity of a score can be a real obstacle with respect to the purposes for which the test was administered, namely to have nomothetic data to confirm or disconfirm clinical hypotheses. Moreover, it can induce the clinician to privilege idiographic interpretations which have many limitations, because they are often based on a qualitative reading of the data that is affected by the subjectivity of the clinician and/or his model of psychopathology. It is also possible that the non-uniformity of a score induces the clinician to "fall back" on the results to the single subtests and/or on the ipsative analysis.

Some researchers are of the opinion that it is possible to use discrepancy scores between subtests that make up the same index to determine whether the score is interpretable. In their view, a high dispersion among the scores that make up the index makes it uninterpretable (Flanagan & Kaufman, 2009). Other researchers take a different view. For example, for Reynolds no level of dispersion among scores makes an Index uninterpretable (Reynolds & Kamphaus, 2015).

Thus, the clinician must ask another question: when an unusual level of variability is detected among the scores that make up an index, what interpretation may be appropriate? This question is consequential to the findings of the research. In fact, no data emerges from the research showing that an index score has less predictive efficacy because of the level of dispersion present among the scores that comprise it (Ryan, Kreiner & Burton, 2002). Reynolds and Kamphaus (2015) are of the opinion that the belief that high variability negatively affects the predictive validity of the index is fundamentally a myth. The clinician can make some assumptions about this finding.

- If the clinician finds an unusual level of dispersion among the scores that make up an index, he or she can ask himself or herself whether the index is a good summary statistical indicator for the variable in question. For example, if there is a difference too large between the subtests that make up the PRI, is the index a good overall representation of Visual Perceptual Reasoning?

- Next, the clinician needs to shift the focus to the subject's functioning and formulate hypotheses congruent with the data available. For example, he might make a further interpretation and hypothesize that the cognitive skills measured come into play in the everyday life. In this case, it is possible to consider what the fallout of a low PSI might be with respect to both specific levels of school/academic performance and everyday life situations.
- The clinician may add in his textological report that the degree of variability among PRI abilities appears unusually high.
- It is possible that the clinician may interpret the level of dispersion as a stand-alone variable or refer, if other data are available, to more specific constructs/skills underlying the index itself.

In summary, if the clinician administers 10 subtests of which 8 are foundational and two are supplemental (Figure Weights and Letter and Number Sequencing), he or she can read the data by referring to 5 broad skills described by the CHC model.

If the clinician also wants to assess the 4 primary factors, i.e., the indices (VCI, PRI, WMI, and PSI), he or she will also need to administer the fundamental subtests Similarities and Arithmetic Reasoning: therefore, to make a double interpretation, 12 subtests must be administered.

CLINICAL CASE: WAIS-IV READING OF RESULTS ACCORDING TO TWO MODELS

We propose as an illustrative clinical case of the use of the CHC model for the reading of the results the case of a young man of 23 years (Giovanni), who requested a consultation, because at a time of difficulty in the continuation of university studies: "I cannot study ... I am more easily distracted than usual and I remember only some information ... if they ask me those, then I pass the exam, otherwise ... I cannot". This difficulty seems to reduce not only his decision-making power (he could do "something else"), but it also has repercussions on his interpersonal relationships and on the consideration he has of himself, for which feelings of inadequacy have appeared, which he cannot justify, in addition to the impossibility of seeing alternatives.

After attending a technical institute - with results "more or less average ... sometimes it was good, sometimes not so much" - he decided to enroll in the faculty of mechanical engineering. The results are discontinuous, but he completes the three-year course. The discontinuity of performance is not an object of concern. The real difficulties begin the first year of the master's degree: he is unable to pass his exams and complains of attentional problems and difficulty in concentrating. All of this translates into feelings of anxiety and depression combined with a feeling of inability to commit to learning.

After a collection of bio-psycho-social data, the following are administered: the WAIS-IV, the Rorschach and the *Dimensional Assessment of Personality Pathology – Basic Questionnaire (DAPP-BQ*; Livesley & Jackson, 2009, It. ed. 2014). Since the patient does not report a "frank" symptomatology, but rather complains of disorders that can be attributed to a multiplicity of causes, it was considered essential to investigate the cognitive-adaptive and personality areas. The assumption is that between cognitive functioning and personality there is a biunivocal relationship as claimed in the literature.

The WAIS-IV, as mentioned elsewhere, allows not only the assessment of operationalized cognitive abilities, but also the effects of emotional interference. Using an instrument that allows to consider specific cognitive functioning puts the clinician in the position to detect the presence/absence of a flexion in a cognitive ability; the failure of any compensatory modalities; the incidence of emotional variables on cognitive functioning.

The administration of the WAIS-IV took place in two successive moments in order to avoid excessive fatigue.

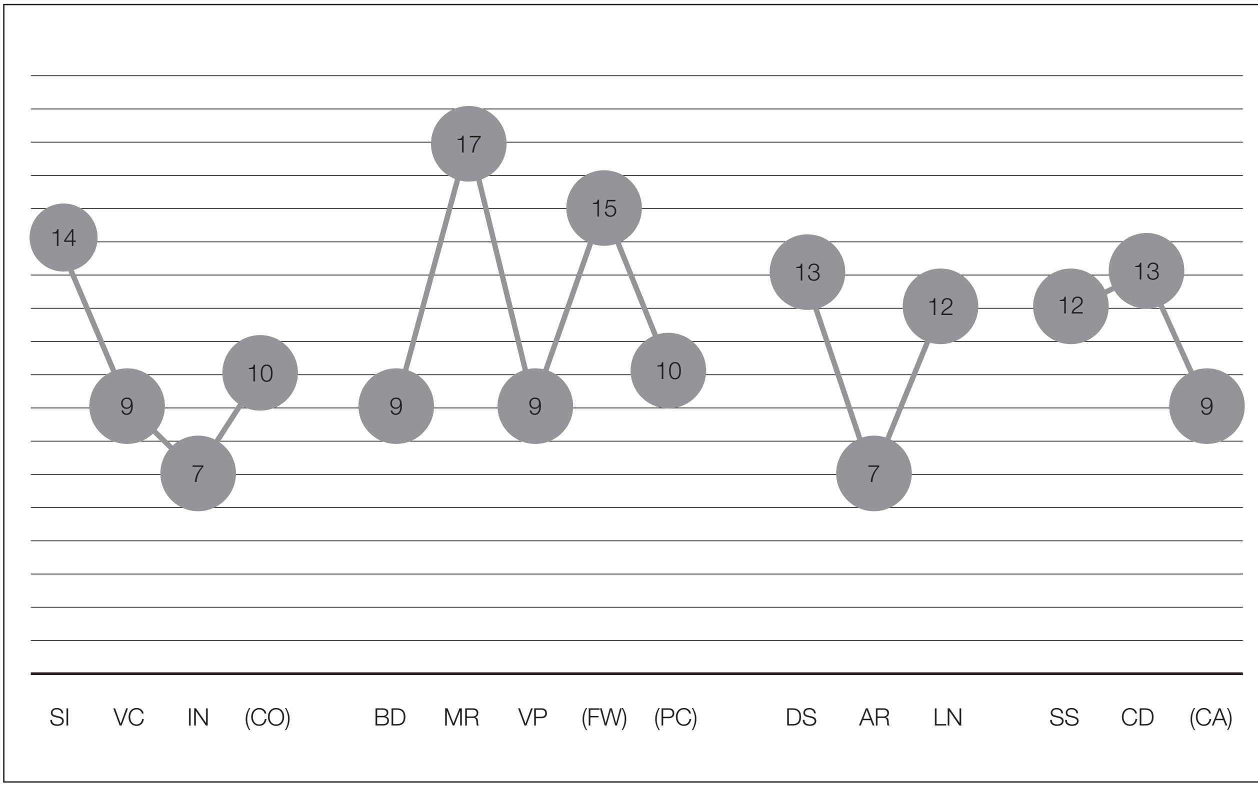
The scale was administered by a clinical psychologist with significant experience in the use of the instrument, and the evaluation of the protocol was supervised by the authors of the article.

Reading according to the 4-factor model

Figure 1 shows the weighted subtest scores that Giovanni obtained on the WAIS-IV.

The patient's performance is not homogeneous meaning

Figure 1 – Profile of Giovanni's scores at WAIS-IV



there are particularly high scores on some subtests, for example, Matrix Reasoning (MR) and Figure Weights (FW) and at the lower end of the mean on other subtests such as Information (IN) and Arithmetic Reasoning (AR).

The composite scores (Indices), which are the "preferred level for clinical interpretation" (Weiss, Chen, Harris, Holdnack & Saklofske, 2010, p. 61), were all found to be of medium/medium-high level.

Table 1 shows the composite scores with their respective confidence intervals (95%), percentile ranks, and qualitative descriptor.

If we consider a fundamental parameter for the interpretation of the Indexes, namely their unitarity, further information emerges. If a score is not unitary, it is improper to attribute to it the meaning it would have if it were unitary because it is not an adequate descriptor of the abilities that the index is intended to measure, and in Giovanni's case (see Table 2) the only unitary index is PSI (medium/medium-high level), so the data that emerged from the WAIS-IV read with the 4-factor model provide the clinician with two pieces of information: the patient has a medium/medium-high total composite score and a Processing Speed Index (PSI) that in turn is medium/medium-high. The non-uniformity of the other indices does not allow for reliable hypotheses regarding the interaction between the different abilities measured by the WAIS-IV.

Table 1 – Giovanni's composite scores

Index	Composite score (IQ)[a]	CI (95%)	Percentile rank	Level[b]
Verbal Comprehension Index (VCI)	100	93-107	50	average
Perceptual Reasoning Index (PRI)	110	103-116	75	average/high-average
Working Memory Index (WMI)	100	93-108	51	average
Processing Speed Index (PSI)	114	104-121	82	average/high-average
Intellectual Quotient (IQ)	108	103-113	69	average/high-average

Legenda. CI = Confidence Interval.
Note. [a] See tables in Orsini & Pezzuti, 2013b, for the conversion of the sum of the weighted scores of each scale in the corresponding Index.
[b] See Orsini & Pezzuti (2013, p. 20, table 2-5)

Table 2 – Assessment of the unitarity of Giovanni's indexes

Index	Max-Min	Max-Min difference	Unitary cut-off (16-69 years)[a]	Unitary Ability
Verbal Comprehension Index (VCI)	14 – 7	7	≥6	No
Perceptual Reasoning Index (PRI))	17 – 9	8	≥7	No
Working Memory Index (WMI)	13 – 7	6	≥5	No
Processing Speed Index (PSI)	12 – 13	1	≥5	Yes
Intellectual Quotient (IQ)	114 – 100	14	≥38	Yes

Note. [a] See Orsini, Pezzuti & Hulbert (2015), Pezzuti (2016) and Lang, Michelotti, Bardelli & Pezzuti (in press) for cut-off values.

Based on this finding, the clinician can formulate the following hypotheses: the subject has the prerequisites (i.e., the cognitive skills) to pass the master's degree examinations; his information processing speed - defined by the authors of the CHC model (Schneider & McGrew, 2012, 2018) as the average speed with which a subject completes a series of simple tasks in succession - is in fact medium/medium-high.

Processing speed is a construct that has been the subject of multiple discussions in the literature because there has been no agreement on its operationalization. For some authors it would be an index of complex attention, mental speed, reaction time, or inspection time, or even information processing time, etc. It is a construct, which is often confused with working memory and attention and consequently has been used interchangeably (Martin & Bush, 2008). We lean toward DeLuca's (2008, p. 266) definition that it is "the time required to perform a cognitive task or the amount of work that can be completed in a defined time frame".

What is of most interest in the clinic of this construct is some data that we list:

- in factor analyses for the study of cognitive abilities, mental speed of information processing has been identified as an important domain of cognitive functioning (Carroll, 1993; Horn & Noll, 1994, 1997; McGrew, 1997; Schneider & McGrew, 2012);
- there is evidence for connections between this construct and other cognitive constructs, such as working memory and fluid intelligence (Fry & Hale, 1996; Kyllonen & Christal, 1990), including the interaction between Baddeley's central executive and this construct (DeLuca, Barbieri-Berger et al., 1994);
- the fact that a slowdown in processing speed adversely affects verbal and visuospatial abilities (Sherman, Strauss et al., 1997), long-term episodic memory (DeLuca, Barbieri-Berger & Johnson, 1994; DeLuca, Gaudino, Diamond, Christodoulou & Engel, 1998; Gaudino, Chiaravalloti, DeLuca & Diamond, 2001), working memory, executive functions, problem-solving skills, and visuospatial skills and school skills such as reading and arithmetic (Chiaravalloti, Christodoulou, Demaree & DeLuca, 2003; Demaree, DeLuca, Gaudino & Diamond, 1999; Kennedy, Clement & Curtiss, 2003; Lengenfelder et al., 2006; Madigan, DeLuca, Diamond, Tramontano & Averill, 2000);
- mental speed correlates less with general intelligence than working memory and is the one that declines first with age as early as age 34 (Pezzuti, Lauriola, Borella, De Beni & Cornoldi, 2019).

The most recent research data only allow us to state that there is "some sort of global, biologically determined mechanism that limits the speed at which information is processed" (DeLuca, 2008, p. 272).

This information, although very important, in this context does not allow the clinician to formulate hypotheses because of the non-unitarity of the other indices.

The lack of unity of the other three indices forces the clinician to become aware of it and to "fall back" on a more idiographic reading. We use the term "fall back" because - as reported in literature - an idiographic reading has many limits.

Reading according to the 5-factor CHC model

If one can make use of the CHC model, the clinician can make a nomothetic evaluation of the data and formulate - based on the above literature data - some additional hypotheses regarding the patient's cognitive functioning; given the purpose of the article, we intentionally do not consider the links to emotional and personality variables.

As it is evident from the results reported in Table 3, because the criterion of unitarity of the broad CHC abilities is met, hypotheses can be made regarding Giovanni's cognitive functioning based on the broad CHC abilities.

The breadth and depth of the knowledge acquired by Giovanni with resp ect to his culture of belonging and the effective use of this knowledge, are partially adequate, given that the patient does not belong to a linguistic minority, has not had language problems in pre-school age and has a level of culturalization for which given the years of schooling should have acquired more knowledge. During the administration, moreover, the subject did not express any particular difficulty in dealing with the tasks proposed by the subtests, except for Vocabulary, where he stated that he had reduced lexical knowledge due to the fact of "being a bad reader" and to prefer video communication.

The score reported at Fluent Intelligence (Gf), even taking into account schooling is well 2 standard deviations above the mean. The authors of CHC and Lichtenberger and Kaufman (2009) operationalize Fluid Intelligence (Gf) as the ability

Table 3 – CHC model applied to the clinical case Giovanni

CHC broad ability	Subtest (WS[a])	Max-Min difference (ws[a])	Unitary cut-off (16-69 years)	Unitary Ability	Sum pp[a]	IQ	CI (95%)	PR[b]	Level[c]
Crystallized Intelligence (Gc)	Vocabulary (9) + Information (7)	2	≥5	Yes	16	89	83-96	27	average/low-average
Fluid Intelligence (Gf)	Matrix Reasoning (17) + *Figure Weights* (15)	2	≥5	Yes	32	135	125-140	98	high/very high
Visual Processing (Gv)	Block Design (9) + Visual Puzzle (9)	0	≥5	Yes	18	94	87-102	40	average/low-average
Short-Term Memory (Gsm)	Digit Span (13) + *Letter and Number Sequencing* (12)	1	≥5	Yes	25	114	105-121	84	average/high-average
Processing Speed (Gs)	Symbol Search (12) + Coding (13)	1	≥5	Yes	25	114	104-121	82	average/high-average

Legenda. CI = Confidence Interval.

Note. [a] Weighted Score; [b] Percentile Rank; [c] Orsini & Pezzuti (2013, p. 20, tables 2-5). The subtests in italics are the supplementary ones.

of inductive and deductive reasoning aimed at identifying common and different aspects, forming concepts, identifying general rules and applying rules to solve new problems. In other words, Giovanni is able to adequately and quickly solve new problems/situations, such as those posed to him by the two subtests, which propose tasks that cannot be performed automatically. Hence the need to be able to make inferences, identify the possible relationships that may exist between the different elements as well as formulate and verify the hypotheses formulated.

The question then arose as to what might be the possible causes of the current difficulties. There are two other clinically interesting pieces of data: Visual Processing (Gv), defined as the ability to create, store, retrieve and transform visual images (e.g., flipping or rotating shapes in space) shows a slight decline compared to other abilities and also considering his level of education. The level of performance in Short-Term Memory (Gsm), which detects the ability to grasp and maintain at a level of awareness information elements present in the current situation, is slightly above normal and 1 *SD* higher than the average performance of subjects of equal education. Giovanni is therefore able to activate cognitive resources to maintain information at a conscious level. This prevents the system, which has a limited capacity, from losing them quickly as they decay.

Another interesting fact is that having split the composite PRI index (which cannot be interpreted as a unitary ability) into two indexes according to the CHC model we also have an explanation for the non-unitarity of the PRI as it is due to a different performance of two distinct cognitive constructs (Gf and Gv), where performance is decidedly higher in Gf and poorer in Gv with a difference of about 41 IQ points.

CONCLUSIONS

The latest research regarding the assessment of scores on the WAIS-IV allows the clinician to make use of "new" scores that support him/her in the interpretation of the results achieved. However, we would like to focus attention on an aspect that we consider fundamental. In clinical practice, the interpretation of test results cannot be divorced from a context of assessment understood as the systematic process of forming and testing hypotheses to detect "the difficulties or failures [one encounters] in dealing with developmental problems and tasks" (Price & Zwolinski, 2010, p. 19). The purpose of an assessment process, therefore, is not to obtain a single score or even a series of test scores (testing), but to consider multiple pieces of information obtained altogether from testing and bio-psycho-social data collection and behavioral observations "in order to arrive at a coherent and comprehensive understanding of the person being assessed" (Bornstein, 2010, p. 147). The sole purpose of testing is "to provoke a phenomenon that is not seen so that it is revealed through its effects on behavior. The test must put the hypothetical construct into action in a way that causes observable outcomes" (Gottfredson & Saklofske, 2009, p. 187). Psychological testing, in fact, is "a process of data collection in which an individual's behaviors are taken as a sample and observed systematically in a standardized setting" (Zhu & Weiss, 2005, p. 310) and is only the beginning of psychological assessment.

The administration and reading of the results to the WAIS-IV occurs in the context of psychological testing, the goal of which is to obtain valid and reliable scores. The reading of test results is therefore one of the indispensable pre-requisites for the drafting of the psychodiagnostic report. Only afterwards the clinician integrates the interpretation of scores with other information coming from different sources (e.g. other instruments, clinical interviews, history, informants etc.) and are re-evaluated in order to understand the specificity of the single case. Only at this point can one speak of psychodiagnostic assessment and it is here that explanatory and intervention hypotheses are generated (Zhu & Weiss, 2005).

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