Vol. 2, Issue 2, 2022 (April – June)

ISSN 2710-4532 (Online) *ISSN 2710-4524 (Print)* *ISSN 2710-4540 (ISSN-L)*

Journal of Educational Research & Social Science Review (JERSSR)

Capturing the Human Brain: an Iterative Analysis of Intellectual Assessment Tools

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Abstract

The main aim of this study is to examine the chronological evolution of the major intelligence tests from the 1880s to 2020s (contemporary times) in order to understand the significant events that marked the field of intelligence testing. This qualitative study used document analysis and the tests were selected through purposive sampling. The time period from 1800s to 2020s was divided into ten sub-periods and each test was analysed iteratively in terms of five aspects: its name and nature, name(s) of authors and publication date, how did it measure intelligence, number and names of subtests and the cognitive functions or factors of intelligence it measured with reference to the previous or contemporary tools. This data is displayed in tabular form followed by an interpretation regarding the key developments of that time period. The main findings reveal that the development of intelligence testing has a rich and iterative history and intelligence instruments have basically evolved from being atheoretical, sensory and motor-based cognitive measures to theoretically driven, psychometrically advanced instruments with high diagnostic capability in order to meet the diverse needs of school counsellors, educators, practitioners and psychologists today. Despite widespread criticism and controversy, the need for intelligence tests will continue as cognitive ability is the basis for all human behaviours.

Keywords: Intelligence Tests, Cognitive Ability, IQ

Introduction

The quest of mankind to capture the working of human mind is existing for many centuries (Anastasi, 1982). Nearly 3000 years ago, the Chinese developed a variety of mental tests in order to select civil servants in their Imperial Court. Similar testing was applied by the ancient Romans and Greeks and in universities of Europe in the Middle Ages (Kaufman & Harrison, 2008; Urbina, 2014). The establishment of the field of psychology as a scientific discipline in the middle of the nineteenth century led to further interest in the study and measurement of this key individual difference known as "intelligence" - informally defined as cognitive ability, intellectual ability or mental ability (Colman, 1990).

Intelligence is an abstract concept or hypothetical entity as it does not possess a concrete, objective or physical reality (Groth-Marnat, 1997; Walters, 2020). This latent trait has primarily been measured through the use of various intellectual assessment tools and instruments. However, it is a complex and widely disputed concept (Richardson, 2022). The definition, nature, characteristics, structure, underlying factors, variables and measurement of intelligence have all been the subject of considerable debate and controversy since the past century. For instance, there are various definitions of intelligence and there is no scholarly agreement as to what precisely constitutes intelligence (Goldstein, 2018).

The intelligence quotient or IQ score which has become synonymous with intelligence has provoked even fiercer debate (Richardson, 2022; Urbina, 2011). There have been scathing accusations of IQ tests being used for wrongful purposes ("eugenics movement" – described as a dark chapter in intelligence history and immigration control), promoting racial bias and discrimination and perpetuating educational inequalities (Frank, 2022; Mackintosh, 1998).

Despite the severe criticism from various quarters, intelligence tests continue to draw immense public attention mainly due to their implications for people's educational and occupational prospects. They are considered to be good predictors of academic achievement, occupational

performance and other domains of life (Nesbett et al., 2012) - for example, correlation between intelligence scores and school achievement is said to be 0.5 (Mackintosh, 2011). However, in recent years some researchers have expressed profound reservations deeming these correlations as inaccurate and meaningless and promoting their cautious use (Richardson & Norgate, 2015; Richardson, 2017)

Nevertheless, there has been a massive proliferation of various intellectual and psychological assessment instruments and cognitive tools over the years predominantly in the United States.

Objectives of the Research

Following are the objectives of this review study:

1. To examine the chronological evolution of important intelligence tests from the 1800s to contemporary times i.e. 2020.

2. To present iterative comparison of factors and sub-factors of tests of intelligence in tabular form.

3. To interpret key developments in each new test to measure intelligence.

Literature Review

Defining intelligence

The term intelligence is taken from *intelligere* having roots from *interlegere which means to choose or pick up* (Traupman, 2007 in Goldstein, 2018). There has been severe contention in trying to develop a standard definition and measure of intelligence (Ford, 2004). Therefore, a number of definitions can be found in the literature some of which are specific while others are more ambiguous in nature (Fogarty, 1999). Boring (1923) stated that intelligence is basically whatever intelligence tests measure. Anastasi (1992) said that intelligence is not a single entity but a combination of several traits that is required to survive and advance in a specific culture whereas Pinter (2000) described it as the capability to adjust oneself in a new situation.

Types of Intelligence Tests

Intelligence tests are psychological tests as they follow a structured set of procedures to evaluate a given behaviour sample that conforms to rigorous standards, moreover, they are referred to as ability tests to differentiate them from personality tests (Urbina, 2014). Pomerantz (2019) distinguishes between three types of cognitive tests: intelligence, achievement and neuropsychological. Intelligence tests measure the cognitive ability or functioning of an individual; achievement tests determine what can be done using those cognitive functions and neuropsychological tests try to identify defects in brain functioning that may arise due to brain injuries or illnesses. They could be based on a single item or could be in the form of a battery that contains various subtests each measuring a different cognitive ability.

According to Urbina (2011), intelligence tests can be categorized in four basic ways: (a) according to administration mode: individually administered tests or group tests; (b) according to age range: targeted at children or adults (c) according to test content: verbal or nonverbal tests; and (d) according to length: comprehensive batteries or brief versions.

(a) *Individual vs. group tests*

Individual tests are highly personalized as they involve one on one interaction between the psychologist or examiner and the examinee. The examiner gets an opportunity to observe the examinee while he responds to the challenging tasks. As a result, more in-depth information can be gleaned from the examinee which can prove to be beneficial in clinical assessment. It is essential that these tests only be administered by highly trained staff because they have to follow procedures that have strict standardization requirements, failing which the reliability of the test could be compromised. However, they are time consuming in nature and expensive to administer.

In group tests, a few individual traits are neglected because these are usually paper-pencil tests requiring less time and having ease of administration and scoring.

(b) *Children vs. adult intelligence scales*

Some intelligence tests are aimed at measuring the cognitive ability of children only such as the Wechsler Intelligence Scale for Children (WISC) whereas others are aimed at adults only such as Wechsler Adult Intelligence Scale (WAIS). Some batteries contain a variety of test items that target both.

(c) *Verbal vs. non-verbal tests*

Verbal tests are developed to measure cognitive functioning using language whereas non-verbal tests do not rely on the language ability of the subjects (McCallum, Bracken & Wasserman,

2001). These are based on the principle that neither reading nor any other language variable should affect the score of the examinee (Naglieri & Prewert, 1990).

A further categorization was made by Anastasi (1988) who differentiated among non-language, non-verbal and non-reading tests. These were performance tests dominantly. The instructions for all such tests could be verbal or non-verbal but performance did not include any verbal actions.

Multidimensional tests measured a range of cognitive traits like memory, reasoning, and attention span such as Universal Test of Non-verbal Intelligence (UNIT) and Leiter-R whereas, unidimensional tests like Raven's Progressive Matrices (RPM) only used progressive matrices to measure a single narrow construct.

(d) *Comprehensive batteries vs. brief versions*

Although most intelligence tests are comprehensive batteries and include a wide range of subtests measuring various abilities, brief versions also known as intelligence screeners (Sparrow & Davis, 2000) have also been developed for speed purposes such as the Kaufman Brief Intelligence Test (KBIT).

Intelligence Quotient (IQ)

The term that has become synonymous with intelligence is the Intelligence Quotient (IQ) although they are not the same. Developed by William Stern, a German psychologist, it was initially calculated in the form of a ratio wherein the mental age (MA) was divided by the chronological age (CA). It was later adopted in the Stanford-Binet by the American psychologist Lewis Terman who later recommended turning the intelligence quotient into a percentage by multiplying it by 100 (Terman, 1916). IQ scores are now measured based on deviations (also known as deviation IQ) from the average intelligence score for the population where the mean IQ score is 100 IQ points and average IQ is within one standard deviation i.e. 15 IQ points.

Characteristics of IQ Tests

Psychometrics is the branch of science that deals with the measurement of educational and psychological tests (Urbina 2014). Intelligence tests need to possess essential psychometric characteristics such as correlation coefficients and matrices, factor analysis, reliability, and validity.

Correlation coefficients show the extent to which two tests are related to one another and can range from +1.00 to -1.00. The plus or minus sign reveals the direction of the relationship (whether positive or negative) whereas the number indicates the strength. The correlations between scores on multiple tests or subtests can be shown on a correlation matrix.

Factor analysis is an important statistical technique that has greatly affected the development of intelligence testing. Its primary goal is to reduce the number of variables or dimensions so that key underlying factors can be identified (Urbina, 2014). There are two kinds of factor analysis: (a) exploratory factor analysis which is used to determine the factors from a set of variables and (b) confirmatory factor analysis which is used for verification of the existing factors and is the first stage of structural equation modeling (SEM).

The accuracy of an intelligence test depends on two main aspects: reliability and validity. Reliability is revealed through the consistency of the results of a test and can be measured by split-half, parallel-form and test-retest correlations. A test has validity if it measures the construct that it has been designed to measure. Face validity, content validity, construct validity and criterion validity are various kinds of validity that have been assured for construction of these tests.

Criticism of Intelligence Tests

Intelligence tests have faced criticism due to multiple reasons. They have been accused of containing items that do not represent real-life contexts, neglecting valuable skills such as wisdom, rationality and creativity and favouring those students who belong to families that have access to better resources, superior facilities and greater educational opportunities as they perform better on them (Sternberg, 2020). Furthermore, the huge differences observed in the average intelligence scores of students belonging to minority cultures compared to those of American white students highlighted a lack of culture and test fairness (Gregory, 2004; Ortiz, Piazza, Ochoa & Dynda, 2018; Naglieri et al., 2022). To counter these observations, psychologists tried to prepare non-verbal tests like Raven's Progressive Matrices (RPM) which avoided focusing on language or factual knowledge (Coleman, 2000). Thus, the current study has focused to highlight differences of purpose, factors and subfactors of latent traits measured through tests for intelligence.

Methodology

Working within interpretive paradigm, the research was qualitative in nature and employed the use of document analysis to conduct a chronological iterative (consistent comparison of previous and current content) analysis of the important intelligence tests from the period of 1800s to the contemporary times. Bowen (2009) describes document analysis as a systematic procedure that involves the review and evaluation of printed and electronic material which can be used to complement other research methods or be used on its own in qualitative research. The data can be interpreted to draw meaning, develop understanding, and construct empirical knowledge (Corbin & Strauss, 2008).

There is a plethora of intelligence and cognitive ability tests currently being used in the educational and psychological arenas in the world. The well-known compendium 'Test in Print' (TIP) published by Buros Center cites all of these. It is in English. Its eighth edition was published in 2011, encompassing 3003 tests, out of which 210 tests assessed intelligence.

The researcher consulted a wide range of articles based on an overview of intelligence testing and the following reference textbooks to purposively select the intelligence tests for the analysis.

Table No.1: *Reference Books Consulted*

Name of Reference Book	Editors (Eds.)	Date of Publication	Publisher
Contemporary Intellectual Assessment: Theories, Tests and Issues (Fourth Edition)	Dawn P. Flanagan and Erin M. McDonough	2018	The Guilford Press: New York
Handbook of Intelligence: Evolutionary Theory, Historical Perspective, and Current Concepts	Sam Goldstein, Dana Princiotta and Jack A. Naglieri	2015	Springer Science + Business Media: New York
The Cambridge Handbook of Intelligence	Robert J. Sternberg and Scott Barry Kaufman	2011	Cambridge University Press: New York
Practitioner's Guide to Assessing Intelligence and Achievement (11th Edition)	Sam Goldstein and Jack A. Naglieri	2009	John Wiley & Sons Inc.: New Jersey

In order to conduct the chronological analysis of the intelligence tests, the time period from 1800s to the present time was divided into ten sub-periods for ease of analysis: a. Origins / Antecedents 1800s; b. 1900 – 1917; c. 1918 -1938; d. 1939 – 1973; e. 1974 – 1980; f. 1980 – 1989; g. 1990 – 2000; h. 2000 – 2004; i. 2005 – 2009; j. 2010 – 2020.

Each of the intelligence tests was analysed in terms of the following characteristics which were tabulated (Columns 1 to 5):

a. name (acronym) and nature of the intelligence test
   The nature included details indicating whether the test was individual or group; whether it was verbal or non-verbal; what age range it catered to and its theoretical orientation.
b. name(s) of author and publication date
c. measurement of intelligence – e.g. IQ quotient, scales, indexes, subtest scores, etc.
d. number and names of subtests
e. cognitive functions /factors/ abilities of intelligence it measured.
   Only the first and latest editions of the intelligence tests were analyzed in the table. Each table was followed by an interpretation by the researcher noting the key aspects of that particular time period with regard to intelligence test development

Results and Discussion

The chronological evolution of the intelligence tests is displayed in the following tables followed by an interpretation of the given table.

Table 2: Origins / Antecedents: 1800s

Name & Nature of Intelligence Test	Author & Publication Date	Measurement of intelligence	Subtests	Abilities/Factors/ Functions
Seguin Form Board **Type:** Individual, non-verbal test for children.	Seguin (1880)	general intelligence measure	The test required placing various geometric shapes into inserts of the same shape (Naglieri & Otero, 2018).	form perception; visual matching and discrimination; eye-hand or psychomotor coordination; cognitive perceptual abilities.

Galton's sensory and motor tests in Anthropometric Laboratory , U.K. **Type:** First comprehensive individual test for children and adults.	Galton (1884)	general intelligence measure	The examination recorded examinee's personal details (e.g. eye and hair colour) and then conducted tests of sensory acuity, stature, strength and lung capacity using specialized instruments.	discrimination of weight; reaction time; strength of squeeze; visual discrimination.
Cattell-Columbia Tests **Type:** Individual test administered to college students	Cattell (1884)	general intelligence measure	The test comprised of measures of reaction time, colour identification, memory related to digits, retrieval of mental images, logic, word association and sensory perceptions.	combination of lower and higher order functions

Table 2 shows that the assessment of intellectual ability can be traced to the use of the Seguin form board, which was prepared by a French psychologist and was a non-verbal intelligence test in 1800s (Naglieri & Otero, 2018). Francis Galton, a pioneer of the scientific measurement of individual differences movement, later developed an array of sensory and motor tests using specialized instruments in his Anthropometric Laboratory which he set up in London, U.K. to measure intelligence. His primary stance was that intelligence depends upon the sensory measures which formulate length and breadth of the experience (Wasserman, 2018). His student James McKeen, an American psychologist, later extended his experimental work and developed the Cattell-Columbia tests at the University of Columbia which were a combination of Galton's tests of sensory and motor discrimination, Cattell's reaction time measures other higher order tasks such as rapid colour naming, memory for digits, logical memory, etc. The term "mental tests" was used by Cattell for the first time in an article he wrote for the British journal Mind (1890).

Although Galton firmly believed that intelligence was a unitary and innate biological trait (Urbina, 2011) neither Galton nor Cattell defined intelligence or explicitly asserted that their tests were measures of intelligence. However, their use of sensory discrimination and reaction time measures as cognitive measures was later discredited. Stella Sharp (1899) concluded in her thesis that their research lacked proof and had no theoretical base whereas Wissler (1901 as cited in Wasserman, 2018) found no correlation between students' academic achievement and the intelligence test scores.

Table 3: 1900 – 1917

Name & Nature of Intelligence Test	Author & Publication Date	Measurement of intelligence	Subtests	Abilities/Factors /Functions
Binet-Simon Intelligence Scale **Type:** Individual, verbal test for children. Adaptive test format	Binet & Simon (1905)	general intelligence measure used graded scale of intelligence	1905 : 30 items (in 20 minutes) 1908 : 56 tests 1911 : ages 3 to adulthood 11 levels (5 items administered at each level) Tasks included placing digits and words in appropriate places, identifying absurd sentences, comprehending difficult sentences and putting things in order.	Memory, attention, reasoning and verbal comprehension were evaluated.
Stanford-Binet Intelligence Test **Type:** Individual, verbal test Adaptive test format	Terman (1916)	general intelligence measure Single age scale Ratio IQ (1937 Deviation IQ (1960 – 1972)	90 items Parallel vocabulary tests 3 to 10 years – 6 items each 12 years – 8 items 14 years – 6 items Adult average – 6 items Superior adult – 6 items	It measured memory, comprehension, visual-spatial and numerical ability with a few words.
Army Alpha Mental Tests **Type:** Group, verbal test for adults. (Administered to	APA Committee headed by Yerkes (1917)	general intelligence measure Grades were ranked from A to D (Very superior	Eight subtests (40 to 50 minutes) These included questions based on common sense, number sequences, synonyms and antonyms, puzzles, and problems of arithmetic.	It assessed language skills, numeracy skills, ability to follow directions and knowledge.

groups as large as 500.		to very inferior on a six-letter scale)	
Army Beta Mental Tests Type: Group, nonverbal test for adults (Administered to large groups)	APA Committee headed by Yerkes (1917)	general intelligence measure Grades A - E	Seven subtests (50 to 60 minutes); the test is administered through using chalk, board, eraser and curtain. Items included examining pictures such as comparing forms and completing drawings.

Table 3 highlights a very productive time period in the field of intelligence testing as a result of significant advances such as the emergence of the first working intelligence test (Binet Simon Scale) and the first large-scale group intelligence tests (Army Mental Tests) including the first non-verbal intelligence test (Army Beta Test).

Alfred Binet and Theodore Simon developed this intelligence scale at the request of the Ministry of Public Instruction to separate children with mental disabilities from regular students for remedial instruction. Unlike Galton and Cattell, Binet firmly believed that in order to measure intelligence, it was necessary to assess higher mental functions instead of lower-order sensory and motor functions. Binet and Simon devised a series of age-related cognitive tests which included verbal comprehension, attention, reasoning and memory to determine a child's mental functioning (Urbina, 2011). Lewis Terman, an eminent psychologist and founder of what is known as the gifted-child movement, also became a renowned translator of the Binet-Simon scale at the University of Stanford. He renamed it as the Stanford-Binet, wherein 60% of the items were from Binet while 40% were Terman's own and from other sources. He was also responsible for introducing the concept known as intelligence quotient (IQ) and asserted that the Stanford Binet measured general intelligence or g – single IQ according to Spearman's theory of intelligence.

The demands of World War I acted as a catalyst for the development of the first large-scale intelligence group test (Army Mental Alpha and Beta Tests) to classify and place army officers for duty according to their abilities. In order to test those officers who were unable to read or write or were not language proficient, the first non-verbal group test (Beta test) was developed. The measurement of intelligence was now no longer based on assessing elementary or perceptual cognitive functions but on higher mental functions. The Stanford Binet and the army mental tests yielded a general intelligence measure in the form of a single IQ quotient largely influenced by Spearman's general intelligence theory which looked at intelligence as a unitary construct.

Table 4: 1918 – 1938

Name & Nature of Intelligence Test	**Author & Publication Date**	**Measurement of intelligence**	**Subtests**
Raven's Progressive Matrices (RPM) and Mill Hill Vocabulary (MHV) Scales Type: Individual or Group non-verbal test – timed (40 minutes) or untimed Age Range : Children and adults	Carlyle (1938) His work was continued by his sons who created a publishing house in 1972 in Scotland called J.C. Raven Ltd that was bought in 2004 by Harcourt Assessment.	2 components of general intelligence (Spearman's g) Educative ability Reproductive ability	3 formats according to the ability of examinees: ▪ Standard Progressive Matrices ▪ Coloured Progressive Matrices (for children, the aged and learning impaired) ▪ Advanced Progressive Matrices (for higher functioning adults such as college students.) Sixty multiple choice questions based on abstract reasoning in the form of matrices.

Table 4 describes an important non-verbal intelligence test called Raven's Progressive Matrices and Mill Hill Vocabulary which was designed by Raven in 1938 in Scotland, United Kingdom. Raven wanted to design a simpler test that could be conducted easily and decided on a non-verbal format as he found the Binet-Simon test lengthy and difficult to administer and interpret.

The key difference between the format of the Army Beta test (first non-verbal test) and the Raven's test was that the latter was unidimensional in nature - all the test items were exclusively

based on matrices – visual geometric designs that had a missing piece. To assess verbal intelligence, its accompaniment, the Raven's Mill Hill Vocabulary Scale (MHV) was administered to examinees in which they had to define words from a list of 88 words (Raven, 2000).

Raven specifically stated that the purpose of the Raven's Progressive Matrices and Vocabulary tests was to measure (a) educative ability and (b) reproductive ability. These are the two main constituents of general intelligence (Spearman, 1927) or g where educative ability means to be able to think clearly and gain insight into complex contexts and reproductive ability means to store and reproduce information.

Raven's Progressive Matrices is extensively used as a culture-fair assessment measure for populations that have limited language proficiency due to its lack of language-based content. However, the test has faced criticism due to its lack of psychometric soundness (Jensen, 1980).

Table 5: 1939 – 1973

Name & Nature of Intelligence Test	Author & Date of Publication	Measurement of intelligence	Subtests	Abilities/Factors /Functions
The Wechsler- Bellevue Scales Wechsler-Bellevue Form I and II **Age range :** 10 to 60 years **Type:** Individual, verbal and non-verbal	Wechsler (1939-1946)	Verbal IQ based on first 5 subtests Performance IQ based on second 5 subtests Full- scale IQ Deviation IQ	This adult intelligence test consisted of ten subtests. An alternative measure was the Vocabulary test.	Verbal and Performance
Wechsler Intelligence Scale for Children (WISC) **Age range :** 5 to 15 years **Type :** Individual, verbal and non-verbal	Wechsler (1949)	Verbal IQ Performance IQ Full Scale IQ	Influenced by the Wechsler–Bellevue Intelligence Scale Its main subsets were general information, general comprehension, picture completion or arrangement, coding, block designs, mazes, arithmetic, object compilation, vocabulary, digit span and similarities. Number Sequences, Labyrinths and Codes were auxiliary tests	Verbal and Performance
Wechsler Adult Intelligence Scale (WAIS) **Age range :** 16 to 89 years **Type :** Individual, verbal and non-verbal	Wechsler (1955)	Full scale IQ Verbal IQ and Performance IQ	Revision of the Wechsler–Bellevue Intelligence Scale (WBIS) comprising of verbal and non-verbal items (performance scales)	Performance and language
Wechsler Preschool and Primary Scale of Intelligence (WPPSI) **Age range :**	Wechsler (1967)	Verbal IQ Performance IQ Full Scale IQ	Eleven subtests including Arithmetic, vocabulary, comprehension and general information,	Performance and language

4:0 - 6:0 years **Type:** Individual, verbal and non-verbal test			Likewise, Similarities and Sentences are *verbal-based* subtests. Picture Completion, Block Design, Mazes and Animal Pegs are the *performance-based* subtests.	
WISC – R (Revised version) **Age range :** 6:0 to 16:0 years **Type:** Individual, verbal and non-verbal	David Wechsler 1974	Verbal IQ Performance IQ Full Scale IQ	Its main subsets were general information, general comprehension, picture completion or arrangement, coding, block designs, mazes, arithmetic, object compilation, vocabulary, digit span and similarities. Number Sequences, Labyrinths and Codes were auxiliary tests.	Verbal and Performance

Table 5 marks the period which brought David Wechsler to the forefront of the field of intelligence testing. His practical, valuable experience as a psychologist and army mental test examiner during the First World War helped him in constructing the Wechsler Bellevue Scales in 1939. The test items of his instrument were unoriginal and had been previously developed by other psychologists (Wasserman & Kaufman, 2015). He believed that general intelligence could be measured through the use of both verbal and non-verbal (performance) tests (Donnell, 2009) and that individual assessment was more accurate than group assessment. Intelligence according to the Wechsler Scales could be measured through three scales: Verbal IQ, Performance IQ and Full Scale IQ which represented g. This represented a major change from having only a single global measure of intelligence.

Wechsler presented a comprehensive definition that intelligence is a general or global capacity of an individual to think and act purposefully and rationally and manage the environment effectively. He developed three age wise tests for pre-school children, adults and for and primary level early graders in 1949, 1955 and 1967 respectively. These tests were changed for some items and age-range later.

The Wechsler intelligence scales went on to supplant the Stanford-Binet (Lubin, Wallis and Paine, 1971 as cited in Wasserman, 2018) and monopolize the field of intelligence testing. The strengths of the Wechsler scales included their practicality and efficiency in administering them but they were criticized due to "technical errors and theoretical shortcomings" (Wasserman, 2018). They were under constant revision. The WISC-R was developed in 1974 and measured cognitive functions such as verbal comprehension, freedom from disparity and perceptual organization. In 1991 WISC III added the function of Processing Speed.

Table 6: 1974 – 1979

Name & Nature of Intelligence Test	**Author & Publication Date**	**Measurement of Intelligence**	**Subtests**	**Abilities/ Factors/Functions**
Psycho-educational Battery by Woodcock Johnson (WJPEB) 1977. **Age range:** 2:0 – 95 years **Type:** Individual, verbal and non-verbal	Woodcock and Bonner (1977)	Broad Cognitive Ability (BCA)	One battery consisting of 3 tests : cognitive ability, achievement and interest. 12 subtests Analysis-Synthesis, Visual Matching, Analogies, Antonyms-Synonyms Concept Formation Knowledge –	Perception. Perceptions, thinking, reasoning, knowledge, comprehension, memory, learning and discrimination

individual test **Theoretical orientation:** Atheoretical			Comprehension, Numbers Reversed, Memory for Sentences, Blending, Spatial Relations, Picture Vocabulary, Visual-Auditory Learning, Quantitative Concepts.	
British Ability Scales **Age range:** 2:6 – 17:6 Years **Type:** Individual, verbal intelligence test	Elliot (1979)	visual IQ, verbal IQ, and general IQ	23 subtests	Reasoning; Speed of information processing; Spatial imagery; Short term memory and retrieval; Perceptual matching; Knowledge application.

Table 6 highlights the entry of two innovative intelligence tests: the Woodcock-Johnson Psycho-Educational Battery (WJPEB; Woodcock & Johnson, 1977) and the British Ability Scales (BAS). Both these instruments were developed as a direct response to the growing criticism of psychologists, practitioners and educationists that the global intelligence scores or summative results (summative IQs) yielded by the traditional tests being used at the time for example, the Stanford-Binet and Wechsler were inadequate measures. Furthermore, there were also serious concerns regarding their inbuilt ethnic, cultural and social bias (Hill, 2005).

There was a dire need for intelligence tests to be more "diagnostic" in nature i.e. be more sensitive to micro-level individual differences by providing specific details regarding the learning style, cognitive strengths and deficits so that appropriate remediation and intervention measures could be developed for students with special needs (Elliott, 1990; Hill, 2005). Understanding the frustration of British psychologists, Collin and Elliott, developed the BAS (originally known as BIS – British Intelligence Scales) especially for British students.

Another distinguishing feature was that both the WJPEB and the BAS measured not only cognitive functioning but also educational achievement. This was clearly reflected in the former's name - Woodcock Johnson Psycho-educational Battery – a battery which included three separate tests based on cognitive functioning, academic attainment and interest.

This greatly benefitted those working in the special education field where in order to identify students who had a learning disability, the "ability/achievement discrepancy model" was primarily used wherein scores of students on standardized intelligence (IQ) tests such as the WISC (learning potential) were compared to those obtained on separate tests of academic achievement in order to note the discrepancy. Now one battery could serve both purposes and discrepancies could be noted due to the availability of norms on the same subjects.

Another distinctive aspect about these tests is that the word "intelligence" was not used as part of their nomenclature – this was a result of growing criticism regarding the concept of intelligence at the time. Initially named as the British Intelligence Scales, the word intelligence was replaced and it came to be called the British Ability Scales (BAS) (Hill, 2005). The WJPEB also avoided the use of the term intelligence quotient instead replaced it with broad cognitive ability (BCA) (Schrank et al., 2016).

The WJPEB had no theoretical underpinnings (Locke, 2011) whereas the BAS was based on various theoretical models including Spearman's g, Wechsler's verbal and performance model among others.

The various revisions of the BAS (1979) include the following: BAS-R (1982); Differential Ability Scales (DAS, 1990, US version of the BAS), British Ability Scales: Second Edition (BAS II, 1996); British Ability Scales 3 (BAS3, 2012).

In 1989, the first revision of the WJPEB, the Woodcock-Johnson Psycho-Educational Battery–Revised (Woodcock & Johnson, 1989a), was published. The Woodcock-Johnson III Tests of Cognitive Abilities (Woodcock, McGrew, & Mather, 2001b) was published in 2001.

Table 7: 1980 – 1990

Name & Nature of Intelligence Test	Author & Publication Date	Measurement of Intelligence	Subtests	Abilities/ Factors/Functions
Kaufman Assessment Battery for Children (K-ABC) **Age range:** 2:5 – 12:5 years **Type:** Individual, verbal test **Theoretical orientation:** neuro-psychological theory	Alan, Kaufman, and Nadine (1983)	Various scales including: Mental processing including Simultaneous and sequential processing Nonverbal and achievement	16 subtests Sequential like number recall and hand movement and word order etc. Simultaneous: Triangles, Photo series, Spatial Memory, Gestalt Closure and Matrix Analogies. *Achievement*: Riddles, Arithmetic, Faces and Places, Reading/decoding and Reading/understanding.	Simultaneous processing; Sequential processing; Mental processing (simultaneous + sequential) ; Achievement.
Woodcock Johnson – Revised Tests of Cognitive Ability (WJ COG - R) **Age range :** 2 – 90+ **Type:** Individual, verbal test **Theoretical orientation:** Model of expanded version/fluid and crystallized reasoning by Horn (1985) (Kamphaus, 1993; Kaufman, 1990)	Woodcock, and Bonner (1989)	Individual subtest scores Two composite scores overall IQ score.	21 subtests : 7 standard & 14 supplemental Long-term retrieval like delayed recall for names, visual and auditory contents. Short-term learning and recall like words, sentences, numbers, and words. *Processing Speed*: Matching through visual scanning and cross comparison *Auditory-Processing*: Completing sounds and words and identifying patterns and blending. *Visual-Processing*: Identification of special relationships and closure. Recognition of pictures. *Comprehension:* of oral and visual features, listening comprehension and analogies. *Fluid Reasoning* comprises concept formation, analysis and synthesis, verbal analogies, and spatial relations. *Quantitative Ability* : Solving sums and calculations.	Short-term memory (Gsm), Long-term memory(Glr), Comprehension (Gc), Processing speed (Ga), , visual and auditory retrieval (Gv), and Fluid reasoning (Gf)
Differential Ability Scales (DAS) – American version. **Age range**	Elliot, (1990)	general cognitive ability (GCA) Clusters : Verbal Ability, Non-verbal	Two test batteries: (a) Preschoolers 2:6 to 5: 11 Divided into 2 categories : 2:6 to 3: 5 (lower) 3:6 to 7:11(upper) (b) School-age children	Verbal and non-verbal clusters, (Gc & Gf), Spatial cluster. Fluid reasoning cluster

2: 6 to 17:11 **Type:** Individual verbal (V)and nonverbal (NV) test **Theoretical orientation:** A mixture of cognitive development theories	Ability, Verbal, Nonverbal and Spatial Ability T scores Ability scores Raw subtest scores	6 : 0 to 17: 11 *Preschool :* Non-verbal patterns like copying, identifying similarities, construction and verbal comprehension like concepts, vocabulary, block building and early numbers. School age: Verbal and non-verbal patterns, similarities, sequential and quantitative recall**,** Matrices, and spatial construction. Identification of words and numbers. Content achievement. Basic Number Skills, Spelling and Word Reading *Diagnostic* Subtests include Recall of Digits, Recognition of Pictures, Matching Letter-Like Forms, Recall of Objects – Immediate, Recall of Objects – Delayed and Speed of Information Processing

Table 7 shows that the intellectual assessment tools during this time period were getting theoretically influenced by the advances made in cognitive science and neuropsychology at the time.

Alan Kaufman was the pioneer of this theory-driven movement; he lamented in his acclaimed book "Intelligent testing with the WISC-R" the gross failure of intellectual tools of that time to incorporate theoretical advancements made by research in cognitive science, psychology and neuropsychology (Kaufman, 1979, p. 4) He developed the Kaufman Assessment Battery Test (K-ABC; Kaufman & Kaufman, 1983) along with his spouse, Nadeen, keeping in mind six goals, the first and foremost being that their instrument should have a theoretical orientation (Narrett, 1984) . It was the first intelligence test that was influenced by the neuropsychological model of brain functioning developed by the Russian psychologist, Alexander Luria and later adapted by Das and his colleagues. This was reflected in their definition which described intelligence as "an individual's style of solving problems and processing information". The K-ABC measured the problem-solving ability of a child in two ways (a) sequentially and (b) simultaneously.

The Woodcock-Johnson–Revised Tests of Cognitive Ability (WJ-R COG; Woodcock & Johnson, 1989c), unlike its atheoretical predecessor Woodcock –Johnson III, also aligned itself with John Horn's expansion of fluid-crystallized (Gf-Gc) theory.

In its original form that was developed by Cattell (1941, 1971) based on Thurstone's factor analysis approach, the Gf-Gc theory conceptualized human cognitive ability as crystallized intelligence (Gc) and fluid intelligence (Gf) (Flanagan and Dixon, 2013). Crystallized intelligence is described as the accumulation of information and verbal skills as a result of education and acculturation that increases with time whereas fluid intelligence is the ability to think in an abstract manner which decreases gradually from middle adulthood. Later, John Horn expanded this dichotomous model into an eight factor model, whereas, seven broad abilities were measured by WJ-R COG who identified, Glr, Gs, Ga, Gc, Ga, Gf, Gsm, and Gv.

Another intelligence test that was also influenced by the cognitive and neurological research advances was the Differential Ability Scales (DAS; Elliott, 1990a). Developed by Colin Elliot as an American version of the British Ability Scales (BAS; Elliott, Murray, & Pearson, 1979, Elliott, 1997a), it was based on a mixture of various theories (Gordon &Elliot, 2001).

Table 8: 1991 – 2000

Name & Nature of Intelligence Test	Author & Publication Date	Measurement of intelligence	Subtests	Abilities/ Factors/Functions
Cognitive Assessment System	Jack, Naglieri	Full Scale score	Basic battery : 8 Standard battery :12	Planning (executive functioning);

(CAS) **Age Range:** 5:0 – 17:0 years **Type:** Individual, verbal Test. **Theoretical Orientation:** Based on PASS theory.	And Das (1997)	Cluster scores Individual subtest scores	*Planning*: Matching number, planning codes and connections. *Attention*: Number detection, expressive and receptive attention. *Simultaneous*: Verbal and special connections, figure memory and non-verbal matrices *Successive* : Identification of word series, sentences, questions, repetition	Attention; Simultaneous processing; Successive processing.
Comprehensive Tests of Nonverbal Intelligence (C-TONI) **Age Range:** 6 to 89 years **Type:** Individual, non-verbal test	Hammill, Pearson, and Wiederholt (1996)	Pictorial Scale (PNIQ) Geometric Scale (GNIQ) Full Scale (NIQ)	6 subtests oral or pantomimed instructions. *Pictorial Object* subtests include, Pictorial Categories, Pictorial Analogies and Pictorial Sequences. *Geometric Design* subtests include Geometric Analogies, Geometric sequences and Categories	
Tests of Non-Verbal Intelligence – (TONI III) **Age Range:** 6:0 – 69:11 **Type:** Non-verbal, individual test	Linda Brown, Sherbenou, & Johnsen (1997)	Single scale	Multiple-choice response format and pantomimed instructions Test item content based on areas such as shape, direction, contiguity, rotation, movement, size, shading and position.	Induction; Deduction; Generalization/ Classification; Analogous reasoning; Discrimination; Seriation; Detail recognition.
Leiter International Performance Scale – Revised (Leiter – R) **Age Range:** 3:0 – 75:0 years **Type:** Individual, non-verbal test	Roid, Lucy Miller. (2013)		20 subtests use pictures and pantomime instructions.	Reasoning; Visualization; Attention; Memory.
Universal Non-verbal Intelligence Test (UNIT) **Age Range:** 5:0 - 17:11 years **Type:** Individual, non-verbal test **Theoretical orientation**: Two-tier intelligence model	Bracken, and McCallum, (1998)	FSIQ –Full Scale Score Memory Quotient (MQ) Reasoning Quotient (RQ) Symbolic Quotient (SQ) Non-symbolic Quotient (NSQ)	Formats : abbreviated, standard And extended battery 6 subtests *Memory :* Object Memory, Spatial Memory, and Symbolic Memory *Reasoning :* Mazes, Cube Design and Analogic reasoning.	Memory; Reasoning; Symbolic processing; Non-symbolic processing.
The NEPSY I **Age Range:** 3:0 – 12 years	Korkman, Kirk and Kemp Originally	Five Core Domain Scores	25 subtests *Attention and Executive :* Clocks, Inhibition, Statue, Animal Sorting, Auditory	Attention and Executive Functioning; Language;

	published in Finnish (1980)	No overall score	Attention Response Set and Design Fluency	Memory and Learning; Visuospatial Processing; Sensorimotor.
Type: Individual, non-verbal test			*Language and Communication* : Speeded Naming, Oromo ter Sequences, Body Part Naming and Identification, Comprehension of Instructions, Phonological Processing, Repetition of Nonsense Words and Word Generation.	
Theoretical Orientation: based on Luria's neuro-psychological theory.	Published in English in 1998		*Sensorimotor* : Fingertip Tapping, Visuomotor Precision, Imitating Hand Positions and Manual Motor Sequences.	
			Visuospatial : Arrows, Picture Puzzles, Route Finding, Design Copying, Geometric Puzzles and Block Construction.	
			Learning and Memory subtests include List Memory, Narrative Memory Sentence Repetition, Memory for Faces, Memory for Names Memory for Designs and Word List Interference.	

Table 8 shows two important developments. The first is the growing influence of Luria's neuropsychological theory on intelligence test development as it can be seen to form the theoretical foundations of two new intellectual assessment tools - the Cognitive Assessment System (CAS; Naglieri & Das, 1997a) and NEPSY I (Korkman, Kirk, & Kemp, 1998a).

Although Luria believed that neurological functioning in children involved three functional units, CAS followed a four factor model while NEPSY adopted a five factor one. (Jarratt, 2005)

CAS was considered to be unique because it was constructed according to a specific theory of intelligence called PASS which represented four kinds of mental processing that included planning, attention, simultaneous and successive. Each was said to be linked with various areas of the brains, cognitive functions and behaviours (Naglieri, Conway & Goldstein, 2007). Planning is the ability to use and apply strategies in problem solving, to self-regulate and to self-monitor. Attention is the ability to focus on a particular set of stimuli in a sustained manner without becoming diverted by external ones. Simultaneous is the ability to merge different sets of stimuli into one interconnected group or whole usually required in visual-spatial tasks. Successive is the ability to use information that has been organized in a well-defined sequence or series. (Naglieri et al.,2014). Its advantages included its ease in administration and scoring, direct correlations with academic achievement and ability to determine specific learning disabilities and identify cognitive processing deficits in children in ADHD so as to guide academic interventions and select specific instructional methods. (Nagleiri & Conway, 2009)

The NEPSY I was created to assess the neuropsychological functioning of children in the five cognitive domains such as language, visuospatial, sensorimotor, memory and learning (Korkman et al., 2007).

The second major trend that can be noted is the development of a number of important non-verbal intelligence tests during this time period such as the Comprehensive Tests of Nonverbal Intelligence (C-TONI), Universal Non-verbal Intelligence Test (UNIT) and Tests of Non-Verbal Intelligence – (TONI III).

The development of these nonverbal measures of cognitive skills reveals that there was a deep ongoing concern that traditional language-based intelligence tests were not precise measures of the

cognitive functioning of students belonging to diverse socio-economic, cultural and linguistic backgrounds and it was imperative that this bias be reduced (Carman & Taylor, 2010). The Test of Nonverbal Intelligence-third edition (TONI-III), and C-TONI were both unidimensional tests whereas the UNIT and Leiter-R were multi-dimensional tests in nature.

Hammill and Pearson (2009) created the Comprehensive Test of Nonverbal Intelligence (CTONI) after a comprehensive review of 36 existing nonverbal cognitive measures to act as either a language-reduced non-verbal test (using only oral instructions) or a non-language nonverbal tests (using only pantomime). Another key strength was that it used two kinds of formats i.e. pictorial and geometric in order to assess analogical, categorical, and sequential reasoning. Neither CTONI nor the CTONI-2 had any theoretical orientation (Hammill & Pearson, 2009).

Other non-verbal assessment tools such as the Universal Nonverbal Intelligence Test, UNIT (Bracken & McCallum, 1998) and the Test of Nonverbal Intelligence (TONI) were totally non-language based. The latter was considered to be appropriate for testing patients that are affected by severe neurological or developmental disabilities such as aphasia, dyslexia, language disabilities, and speech impediments as well as those who are not language proficient. The TONI-3 did not have any theoretical orientation. It was originally developed in 1982 (Brown et al., 1982) and revised in 1990 Toni-2 (Brown et al., 1990). The TONI-3 (Brown et al., 1997) is the third version and comparatively shorter in length.

Another nonverbal intelligence test that was developed was the Leiter International Performance Scale – Revised Leiter –R (Roid & Miller, 1997). The original Leiter was actually developed in 1979. The revised version was a non-language based battery that used manipulatives and an easel design. It was theoretically influenced by the fluid-crystallized intelligence model and the Cattell-Horn-Carroll cognitive model CHC (Cattell, 1943; Carroll; 1993; Horn, 1994; Horn & Cattell, 1966) by McGrew and Flanagan (1998) and was helpful for the diagnosis of children who had autism, speech issues and intellectual deficiencies.

Table 9: 2000 – 2005

Name & Nature of Intelligence Test	Author & Publication Date	Measurement of intelligence	Subtests	Abilities/ Factors/Functions
Woodcock-Johnson III Test of Cognitive Abilities **Age Range:** 2:0 – 90+ years **Type:** Individual, verbal test **Theoretical Orientation:** CHC Theory	Woodcock and Bonner (2001)	GIA - General Intellectual Ability GIA Brief GIA Standard GIA Extended GIA Early development GIA Bilingual	31 subtests *Standard Battery* : Verbal Comprehension, Visual-Auditory Learning , Spatial Relation, Sound Blending, Concept Formation , Visual Matching, Numbers Reversed, Incomplete Words, Auditory Working Memory and Visual - Auditory Learning - Delayed *Extended Battery* : General Information , Retrieval Fluency, Picture Recognition, Auditory Attention, Analysis-Synthesis, Decision Speed Memory for Words, Rapid picture Naming, Planning and Pair Cancellation *Diagnostic Supplement* : Memory for Names, Visual Closure Sound Patterns – Voice, Number Series, Number Matrices, Cross Out, Memory for Sentences, Block Rotation, Sound Patterns – Music Memory for Names – Delayed	Gc Gf Gsm Gs Ga Glr Gv

			Bilingual Verbal Comprehension English/Spanish	
Wechsler Intelligence Scale for Children (WISC IV) **Type:** Individual verbal test **Age Range:** 6:0 to 16:11 **Theoretical orientation :** No theoretical orientation	Wechsler (2003)	Verbal Comprehension Index Perceptual Reasoning) Index Working Memory Index Processing Speed Index Full-Scale IQ	15 subtests 10 core (c) : 5 supplemental (s) *VCI* subtests Vocabulary, Similarities, Comprehension, Information (s) Word Reasoning (s) *WMI* subtests Letter-Number Sequencing, Digit Span , Arithmetic (s) *PRI* subtests Matrix Reasoning , Picture Concepts, Block Design Picture Completion (s) *PSI* subtests Symbol Search , Coding and Cancellation (s)	Gf Gsm Gs
The Stanford-Binet Intelligence Scales (SB5) **Type:** Individual, verbal and non-verbal test. **Age Range:** 2 – 85+ **Theoretical Orientation:** CHC theory	Roid (2003)	Full Scale IQ Verbal IQ Non-verbal IQ 5 Factor indexes	*Nonverbal* : Object-Series/Matrices, Picture Absurdities, Procedural Knowledge, Quantitative items Form patterns/Formboard items and Delayed Response. *Verbal :* Early Reasoning, Verbal Absurdities/ Analogies, Vocabulary, Verbal quantitative items, Innovative Position and Direction items and Sentence Memory/Last Word	Fluid Reasoning Quantitative Reasoning Knowledge Working Memory Visual -Spatial Memory
The Kaufman Assessment Battery for Children- Second Edition. **Type:** Verbal and non-verbal **Age Range:** 3:0 - 18:11 years **Theoretical Orientation:** dual theory: 1. neuro-psychological model (Luria) 2. CHC theory	Kaufman & Kaufman (2004)	2 composite scores: a. Mental Processing Index (Luria model) b. Fluid-Crystallised Index (CHC model) Learning Index (Glr) Sequential Index (Gsm) Simulataneous Index (Gv) Planning Index (Gf) Knowledge/Gc Index Non-verbal Scale	18 subtests (core and supplementary) *Sequential :* Number Recall, Word Order and Hand Movements *Simultaneous:* Rover, Triangles, Block Counting, Gestalt Closure, Face Recognition and Conceptual Thinking. *Planning:* Story Completion and Pattern Reasoning. *Learning* : Rebus, Atlantis and Delayed Recall. *Knowledge* (CHC Model only): Riddles, Verbal Knowledge and Expressive Vocabulary.	Simultaneous / Visual (Gv) Sequential / (Gsm) Planning / (Gf) Learning /(Glr) Comprehension knowledge (Gc) included in the CHC model only

Table 9 shows the growing influence of CHC theory on the theoretical orientation of a number of intelligence tests at the beginning of the twenty-first century for instance the Woodcock-

Johnson III Test of Cognitive Abilities, the Stanford-Binet – Fifth Edition: 2003 and the Kaufman Assessment Battery for Children- Second Edition: 2004.

An amalgamation of the theoretical conceptualizations of intelligence delineated by three eminent psychologists, the CHC theory is regarded as the most detailed and psychometrically verified theory about the construction of human cognitive abilities. It began with Raymond Cattell's (1941, 1971) theorizing intelligence as consisting of two main types i.e., fluid intelligence (Gf) and crystallized intelligence (Gc). His theory was later further extended by his student John Horn and merged with Carroll's hierarchical theory which comprised of three strata of abilities: (a) Stratum III representing a general factor (b) Stratum II consisting of 8 broad factors and (c) Stratum I made up of approximately 70 narrow abilities.

Woodcock-Johnson III - Test of Cognitive Abilities which was previously atheoretical in nature now became aligned with CHC theory and explores cognitive functioning in seven broad cognitive domains. Furthermore, its diagnostic subtests could aid in the identification of Attention Deficit Hyperactive Disorder (ADHD), autism, visual impairment and also giftedness (Abu-Hamour et al., 2012)

In fact, the Kaufman Assessment Battery for Children- Second Edition: 2004 went a step further and provided two theoretical frameworks: CHC theory and neuropychological theory.

Similarly, the Stanford-Binet also became influenced by the CHC theory. Another key feature it contained was that all the five main factors could be measured through the use of verbal or nonverbal subtests (Roid & Tippin, 2009)

The WISC-IV was revised in 2003 but it did not have any theoretical orientation. However, there was a key difference that instead of the previous two indexes (VIQ and PIQ) there were now four indexes including Perceptual Reasoning Index, Verbal Comprehension Index, Working Memory Index and Processing Speed Index in addition to a full scale IQ (Kezer & Arik, 2012).

Table 10: 2005 – 2010

Name & Nature of Intelligence Test	**Author & Publication Date**	**Measurement of intelligence**	**Subtests**	**Abilities/ Factors/Functions**
The Wechsler Nonverbal Scale of Ability (WNV) **Age Range:** 4:0 – 7:0 8:0 – 21:0 **Type:** Individual, non-verbal test.	2006	Full-Scale Score	6 subtests 2 versions : two subtest and four subtest version) **Subtests:** Coding (CD), Matrices (MA), Object Assembly (OA), Spatial Span (SSp), Recognition (RG), Picture Arrangement (PA)	General ability
The Differential Ability Scales (DAS) – Second Edition **Age Range:** 2:6 to 8:11 5:0 to 7:11 **Type:** Individual, verbal test **Theoretical Orientation:** CHC theory	Elliot (2007)	GCA General Conceptual Ability SNC Special Non-Verbal Composite Core Clusters	20 subtests <u>Early Years Battery</u> : Lower Level - ages 2:6 -3:5 4 core + 3 diagnostic Upper Level) - ages 3:6 – 8:11 6 core + 10 diagnostic <u>School-Age Battery:</u> ages 5:0 – 17:11 6 core + 8 diagnostic *Core :* Matrices, Word Definitions, Verbal Similarities, Pattern Construction, Recall of Designs, Sequential and Quantitative Reasoning *Diagnostic* : Recognition of Pictures, Phonological Processing Rapid Naming, Speed of Information Processing, Recall of Objects – Immediate, Recall of Objects – Delayed, Recall of Digits – Forward Recall of Digits – Backward	Gc Gf Gsm Gs Ga Glr Gv

			and Recall of Sequential Order.	
The NEPSY-II **Age Range:** 3 – 16 years **Type:** Individual test **Theoretical Orientation:** Luria's neuropychological model (1980)	Korkman, Kirk and Kemp (2007)		36 subtests *Attention and Executive Functioning* (similar to NEPSY I) *Language* (similar to NEPSY I) *Memory and Learning* (similar to NEPSY I) *Sensorimotor* (similar to NEPSY I *Visuospatial Processing* (similar to NEPSY I) NEW ADDITION *: Social Perception*: Affect Recognition and Theory of Mind	Attention and Executive Functioning; Language; Memory and Learning; Visuospatial Processing; Sensor motor; Social Perception.
Wechsler Adult Intelligence Scale – Fourth Edition (WAIS-IV) **Type:** Individual, verbal test **Age Range:** 6:0 to 16:11 **Theoretical Orientation:** CHC theory	2008	Verbal Comprehension Index (VCI) Working Memory Index Perceptual Reasoning Index Processing Speed Index Full Scale IQ	15 subtests (10 core : 5 supplemental) Vocabulary, Similarities and Comprehension (Optional: Information and Word Reasoning) Picture Concepts, Block Design Matrix Reasoning (Optional : Picture Completion) Letter Number Sequencing and Digit Span (Optional: Arithmetic) Coding, Symbol Search (Optional: Cancellation)	Gc Gf Gsm Gs
CTONI-2 **Age Range:** 6:0 to 89:11 **Type:** Individual, non-verbal test	Hammill, Pearson, And Wiederholt (2009)	Pictorial Scale (PNIQ) Geometric Scale (GNIQ) Full Scale (NIQ)	6 subtests *Pictorial Objects* : Pictorial Analogies, Pictorial Categories and Pictorial Sequences *Geometric Designs* : Geometric Analogies, Geometric Categories and Geometric Sequences	analogical thinking; categorical formulation; sequential reasoning.

Table 10 shows that test developers were in the process of making further modifications and revisions to some of the major non-verbal intellectual tests as their new versions were launched for example, NEPSY II and CTONI 2. The function of social perception was added in NEPSY-II. The Wechsler Scales also developed their own non-verbal test version called the Wechsler Nonverbal Scale of Ability (WNV) in order to assess diverse populations.

Differential Ability Scales II and the Wechsler Adult Intelligence Scale IV could no longer remain unaffected by the theoretical influences and became aligned with the popular CHC theory.

Table 11: 2010 – 2020

Name & Nature of Intelligence Test	**Author & Publication Date**	**Measurement of intelligence**	**Subtests**	**Abilities/ Factors/Functions**
The Wechsler Preschool and Primary Scale of Intelligence – Fourth Edition **Age Range:** 2:6 – 7:7 years	Wechsler (2012)	Younger battery: 3 main index scores VSI, VCI, WMI. 3 auxiliary index scores NVI, VAI,	2 batteries for children Age Range : 2:6 – 3:11 years (5 primary & 2 secondary subtests) *Verbal Comprehension* General information, vocabulary, picture identification and receptive *Visual Spatial* Object Assembly, *Working memory and block design*,	Visual Spatial; Verbal Comprehension; Working Memory; Fluid Reasoning; Processing Speed.

Type: Individual , verbal and non-verbal test **Theoretical Orientation**: Broad theoretical framework		GAI. Older battery: 5 main index scores VSI, VCI, FRI, WMI, PSI 4 auxiliary index scores VAI,NVI,GAI, CPI FSIQ	*locations, and picture identification* Age Range : 4:0 – 7:7 years (10 primary & 5 secondary subtests) *Verbal Comprehension:* Vocabulary, information, comprehension and similarities *Visual Spatial:* Assembling and block design *Fluid Reasoning*: Pictorial concepts Matrix reasoning *Working Memory: Locating Zoo and picture identification* *Processing Speed:* Searching bugs & animals, cancellations	
Leiter International Performance Scale – Third Edition (Leiter - 3) **Age Range:** 3:0 – 75:0 years **Type:** Individual, non-verbal test.	Roid and Miller (2013)		20 nonverbal subtests *Fluid Intelligence* : Analogies and classification (CA), form completion (FC), Matching (M/RP) and sequence. *Attention and Memory*: Attention span, (AS), Forward and reverse memory (FM & RM), Attention stroop (NS) and Attention divided (AD) *Social-Emotional Examiner Rating Scale :* Social and emotional rating scale measured mood regulation, feelings and energy, sensory reactivity, impulse control, anxiety, sociability and activity level.	Fluid intelligence; Visualization; Memory; Attention.
Cognitive Assessment System – Second Edition CAS 2 **Age range:** 5:0 – 18:11 **Type:** Individual, verbal test **Theoretical Orientation:** PASS theory **Other variations:** CAS2: Espanol/Brief/ Rating Scale	Naglieri, Das & Goldstein (2014)	Scores for the four PASS neuro-cognitive processes Full Scale Score	Core Battery - 8 subtests (40 min) Extended Battery - 12 subtests (60 min) Subtests: *Planning:* Planned Codes, Planned Connections, Planned Number and Matching. *Simultaneous*: Figure Memory, Matrices and Verbal-Spatial Relations. *Attention:* Receptive Attention, Expressive Attention and Number Detection. *Successive:* Word Series, Visual Digit Span and Sentence Repetition /Sentence Questions. *Intervention Options*: Planning Strategy Instruction and PASS Reading Enhancement program.	Planning; Simultaneous; Attention; Successive.

The Woodcock -Johnson IV **Type:** Verbal **Age Range:** 2:0 – 90 + **Theoretical Orientation:** CHC Theory	Woodcock a nd Johnson (2014)	3 cognitive composites: GIA General Intellectual Ability BIA Brief Intellectual Ability the Gf-Gc Composite	18 subtests Standard (10) Extended Battery (8) Subtests: Oral Vocabulary, Synonyms & Antonyms, Number Series, Verbal Attention, Letter-Pattern Matching, Phonological Processing, Story Recall, Visualization, General Information, Concept Formation, Numbers Reversed, Number-Pattern Matching, Nonword Repetition, Visual-Auditory Learning, Picture Recognition, Analysis-Synthesis, Object-Number Sequencing, Pair Cancellation and Memory for Words.	Gc Gf Gsm Gs Glr Gv Ga
The WISC-V **Type:** Verbal **Age Range:** 6:0 – 16: 11 **Theoretical Orientation:** Influenced by CHC theory	2014	FSIQ index scores (5 primary; 7 ancillary; 3 complemen-tary) Nonverbal Index (NVI) General Ability Index (GAI) Cognitive Proficiency Index (CPI)	21 subtests Primary subtests : 10 Secondary subtests : 6 Complementary subtests : 5 *Primary subtests*: Similarities, Vocabulary, Block Design, Visual Puzzles, Matrix Reasoning, Figure Weights, Digit Span, Picture Span, Coding and Symbol Search.	Verbal Comprehension; Visual Spatial; Fluid Reasoning; Working Memory ; Processing Speed.
The Reynolds Intellectual Assessment Scales, Second Edition and the Reynolds Intellectual Screening Test, Second Edition Published **Age Range:** 3:0 – 94:0 years **Type:** Individual, verbal test.	Reynolds, and Kamphaus (2015)	Verbal Intelligence Index (VIX) Nonverbal Intelligence Test (NIX). Composite Intelligence Index (CIX) (global intelligence estimate)	8 subtests *Intelligence*: What's Missing, Guess What, Odd-Item Out and Verbal Reasoning. *Memory*: Nonverbal Memory and Verbal Memory. *Processing speed:* Speeded Naming Task and Speeded Picture.	Verbal intelligence or crystallised abilities; General intelligence or fluid reasoning; Nonverbal intelligence or visual & spatial abilities; Processing speed or decision speed /reaction time; Memory or short-term memory and learning.
The Universal Nonverbal Intelligences Test- Second Edition (UNIT 2) **Age Range:** 5:0 – 21:0	McCallum and Bracken (2016)	Full Scale IQ Composite scores Subtest scores	6 subtests *Memory*: Symbolic Memory and Spatial Memory. *Fluid Reasoning*: Analogic Reasoning and Cube Design. *Quantitative Thinking*: Numerical Scales and Non-symbolic Quantity.	Memory; Fluid Reasoning; Quantitative Thinking.

Type:	Individual, non-verbal test
Theoretical Orientation:	CHC theory

Table 11 shows the launch of the new editions of the major contemporary intellectual assessment tools. This depicts that constant modifications and revisions are being made to update assessment tools with respect to theoretical orientation and psychometric sophistication.

For instance, the Leiter-3 was modified in order to be less time consuming and more interesting, and offer various scoring options such as a global score, composite and subtest scores. The CAS2 was further enhanced by linking its diagnostic capability with specific intervention plans.

There were many changes made to the WISC-V. One major change was that instead of four factors as in the previous edition, now there were five primary indexes: Fluid Reasoning Index , Visual Spatial Index, , Working Memory Index , Verbal Comprehension Index and Processing Speed Index . The Perceptual Reasoning Index (PRI) was substituted by the Visual Spatial Index and Fluid Reasoning Index.

The Woodcock Johnson IV extended the range of cognitive abilities it could measure alignment with CHC theory. It provided a new measure called the Gf-Gc Composite which could be used for comparison purposes. In order to enhance the diagnostic capability of the test, new tests and clusters were developed.

The Reynolds Intellectual Assessment Scales, Second Edition RIAS-2 (Reynolds & Kamphaus, 2015) was developed to measure verbal and nonverbal intelligence, general ability, memory, and processing speed. Two new subtests based on measuring processing speed were added to the second edition. Furthermore, a shorter version consisting of only two subtests called the Reynolds Intellectual Screening Test, Second Edition (RIST-2) was also developed.

Discussion and Conclusion

This analysis shows that the chronological evolution of intellectual assessment tools has been marked by many significant changes with regard to their theoretical development, psychometric sophistication and diagnostic capability. Naglieri (2015, 2022) states that the contemporary intelligence tests which he calls second generation intelligence tests have several key advantages over the traditional intelligence tests. They have a strong theoretical foundation, exhibit fairness to people belonging to diverse ethnic, language, cultural and marginalized groups; offer multiple scores; are diagnostic in nature and able to identify individuals with special needs and can also be linked to the development of appropriate intervention strategies and remedial measures.

There has also been a marked rise in the number of factors that are measured by contemporary intelligence tests (Frazier & Youngstrom, 2007). Sensory discrimination measures which were earlier discredited as being lower order mental functions are now included as part of the repertoire of cognitive functions that are measured (Wasserman, 2018). Furthermore, the influence of CHC theory has been tremendous in affecting the development of various contemporary intelligence tests. However, in recent years critical reviews of CHC theory have been conducted citing serious discrepancies in its theoretical framework and assessment (Canivez & Youngstrom, 2019; McGill & Dombrowski et al., 2019; Wasserman, 2019).

The evolution of intelligence testing has a rich and contested history but as Urbina (2011) points out intelligence tests, now more commonly referred to as cognitive ability tests have a future ahead as all human behaviours basically entail cognitive abilities.

Recommendations

- For mitigating differences of culture, class, race, gender and context, generalised and non-verbal abilities need to be focused.
- Indigenous tests for specific territories should be encouraged to accommodate isolated populations in the world.
- Tests for measuring multiple intelligence need to be prepared through psychometric standards.
- The traits for creativity and insight need to be incorporated in standard intelligence tests.

- Integration and associations of affective and psychomotor domains need to be established with cognitive ability.

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