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Review Article

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An Overview of Trends in Assessing Intelligence

Malini Srivastava[1] and Deepak Goel[2]*

[1]Psychiatry (Clinical Psychology Unit), Himalayan Institute of Medical Sciences–Swami Ram Himalayan University, India

[2]Neurology, Himalayan Institute of Medical Sciences–Swami Ram Himalayan University, India

***Corresponding Author:** Deepak Goel, Neurology, Himalayan Institute of Medical Sciences–Swami Ram Himalayan University, India.

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Abstract

This article proposes that current practices to assess intelligence does not contribute much in evaluating neurocognitive features of brain functions. From a neurocognitive perspective ongoing practices of intelligence testing have limitations to propose elementary neuropsychological features like executive functions, memory, and visuospatial abilities. The concept of a 'g' factor does not support the idea of independent contribution of other important cognitive domains in overall intelligence scores and it does not include even the primary cognitive functions in intelligence construct. The new advancements in assessing intelligence propose to include the neurocognitive domains with their independent performance scores. It is also being debated whether to exclude IQ as a global intellectual score and use standard scores (such as T, z or percentiles) for the individual tests and cognitive domains.

Keywords: Intelligence; IQ; Neuropsychological Assessment; Cognitive Abilities

Abbreviations

WAPIS: Wechsler Adult Performance Intelligence Scale; WAIS: Wechsler Adult Intelligence Scale; PGI-BBD: Post Graduate Institute of Chandigarh- Battery of Brain Dysfunction; I.Q: Intelligence Quotient

Introduction

In neuro psychology intelligence and intelligence testing are the well - known focal theme. Intelligence is the best characterized subject still with numerous questions. It is something that help us plan, reason, solve problems, quickly learn, make a decision and adjust in the world. At the same time, intelligence is a significant ability in the neuropsychological appraisal. Performance Intelligence quotients and verbal intelligence quotients are an essential part of neuropsychological appraisal for assessing the execution of mind. Intelligence testing in neuropsychological assessments are being used by the clinicians regularly [1]. The neuropsychological test batteries and intelligence tests used for common purpose measures related underlying abilities [2] and most of the time provide the highly correlated results [3].

The aim of this review is, 1) to evaluate the purpose of intelligence tests, 2) to recognize the limitations of intelligence construct while assessing the cognitive functions, 3) to explore the possibilities of including cognitive functions while assessing intelligence.

Presented discussion will be helpful to understand the current practices of intelligence measures and the emerging trends in this field. This review will also propose why we need to consider the change in assessment practice of intelligence.

Materials and Methods

Research articles of last 20 years published in national and international journals were explored through online library.

Results and Discussion

The purpose of intelligence tests

The attempt to measure intelligence represents one of the major accomplishments in the past few decades. A tremendous amount of research has been directed to explore the process of intellect and intellectual activities. The very first procedure to assess intelligence was documented in 1904, when the ministry of Education in France commissioned Alfred Binet and Theophile Simon to find out some system to distinguish between mentally retarded and normal children at school. To reach this goal Binet and Theophile developed a developmental scale describing the types of abilities that were normally expected at different ages [4,5]. This procedure followed by the concept of IQ introduced by Stern [6] and Terman [7]. In spite of the concept of intelligence quotient, significant controversy maintained about the assessment outcome of these intelligence tests. Arguments against these controversies were :1) about the general intelligence factor which can be measured and even quantified and predict about the general intelligence of the person. 2) there are varying cognitive abilities, not a single one, still, an average compound test scores are not adequate.

These two arguments are bases on followings models of intelligence test.

The "g" intelligence factor

Spearman (1904, 1923) hypothesized a two-factor theory of intelligence. He supposed that any test measures a g factor common to all other cognitive tests; and a specific factor (s) unique to that particular test. The relation between g and s components may be variable, but g is always included in any cognitive tests. Tests without the g factor may be tests of sensory or motor abilities, but they do not represent cognitive tests.

The existence of this g factor constitutes the theoretical basis to accept that intelligence can be quantitatively measured using a simple score (lQ). Spearman's theory was subjected to diverse fundamental criticism on empirical grounds. However, "while Spearman was aware that his theory had been empirically refuted, he continued to emphasize the importance of a common factor in intelligence" [8].

Multiple - factor approaches

The second point of view was of L. L. Thurstone [9,10], who developed factor analysis, and, introduced new concepts and more refined procedures in factor analysis, such as oblique-factor structure and centroid methods. He proposed a relatively limited number of factors that would correspond to the fundamental or primary mental abilities: Space, Verbal Comprehension, Word Fluency, Induction, Perceptual Speed, Deduction, Rote Learning, and Reasoning.

He supposed that each factor should correspond to certain specific nervous system activity. Further studies [11] have significantly supported most of the original primary factors proposed by Thurston [12-14] took a somewhat different approach. He proposed a three - dimensional classification of intelligence including contents (letters, numbers, words, and behavioral descriptions); operations (memory, evaluation, convergent thinking, and divergent thinking); and products (units, classes, relations, systems, transformations, and implications). Consequently, according to Guildford, 120 different intellectual abilities could be distinguished. He supposed that empirical data would support the existence of this high number of intellectual abilities.

Cattell [15] proposed the idea of "Fluid Intelligence" (corresponding to and reflecting a pattern of neurophysiological and incidental learning influences) and "Crystalized Intelligence" (highly sensitive to each person's unique cultural, educational, and environmental experiences).

Cattell's distinction between two different types of intelligence is similar to the two major intellectual factors proposed by Hebb [16]: Intelligence A and Intelligence B. Intelligence A represent the basic biological ability to acquire knowledge. Intelligence B reflects the influence or expression of acculturation, education, and personal experiences.

Gardner [17] proposed model of intelligence based on his observations: (1) Damage in different neural structures may result in impairing certain abilities while sparing other abilities; (2) non – brain - damaged individuals intellectual abilities may be dissociated and even extremely dissociated. (3) Every type of ability is identified by a specific set of operations related to a neural mechanism; and indicating about the brain organization of cognition. (4) Different cognitive abilities ("intelligence") develop independently in a child. (5) different bits of intelligence may have different origins in subhuman species and may have evolved in different ways. (6) Psychometric studies support the independence of different cognitive abilities; Gardner insists that psychometric research has not investigated widely enough the diversity of intellectual abilities that are observed in real contexts. Gardner proposes six different types of intelligence: Linguistic, musical, logic - mathematical, spatial, body - kinesthetic, and personal. This group of intelligence may partially correspond to Turnstone's primary mental abilities. However, Gardner is relying not simply on psychometric procedures but also on a broad array of contemporary research, including contemporary neuropsychology.

Sternberg's triarchic theory

Sternberg [18] defined intelligence as "the mental activity underlying purposive adaptation to, shaping of, and selection of real - world environments relevant to one's life" (p. 69). Sternberg [18] has attempted to apply his interpretation of intelligence to testing in the field of intelligence and the understanding of lifelong learning. His interpretation of intelligence allows significant cultural variations and emphasizes the understanding of the behavioral context.

A processing speed test in intelligence testing

It has also been proposed that intelligence depends on what may be called "the neural efficiency of the brain" [19]. Several recent studies have demonstrated that the time required to perform some simple perceptual tests are significantly correlated with psychometric intelligence test scores. Jensen [20] observed a correlation between choice reaction time and scores on intelligence tests. These correlations, however, were not particularly impressive (about - 0.20 to - 0.30). It was observed that reaction time was inversely correlated with IQ and measures thought to singly predict approximately 10 - 15% of the variance in IQ [8]. Higher correlations on the order of - 0.40 using more complex reaction time techniques have been reported by Frearson and Eysenck [21].

Advance orientation in intelligence tests - a neuropsychological perspective

Some attempts have been made to approach the concept of intelligence and to develop intelligence test batteries based on a neuropsychological perspective. Two of these attempts will be briefly examined: The Kaufman Adolescent and Adult Intelligence Test [22,23] and the Cognitive Assessment System [24,25]. The KAIT provides three types of scores: fluid, Crystalized and Composite IQS. It is applicable to people between the ages of 11 and 85. According to the authors, the tests were developed based on the models of Piaget's formal operations and Luria's planning ability in an attempt to include high - level decision - making tasks (Luria's third functional unit).

The Crystalized Scale includes Definition. Auditory Comprehension, Double Meaning, and Famous Faces subtests. The fluid Scale includes Rebus Learning. Logical Steps. Mystery Cards and Memory for Block Designs. The KAIT also includes two additional subtests (Rebus Delayed Recall and Auditory Delayed Recall) and a supplement test (Mental Status). Each IQ (fluid, Crystalized, and Composite) has a mean of 100 and a standard deviation of 15.

Naglieri and Das [25] suggested that intelligence should be seen as a cognitive construct. They base their intelligence theory on Luria's interpretation of the three brain functional units (motivation, emotion, processing-storing information, and planning controlling behavior). They assume that intelligence consists of these three components: attentional processes that provide focused cognitive activity, information processes of two types (simultaneous and successive), and planning processes that provide control of attention; the use of information processes, internal and external knowledge, and cognitive tools; and self - regulation to achieve desired goals [26].

They refer to their theory as the Planning, Attention, Successive, Simultaneous (PASS) theory of intelligence [24]. They then developed a Cognitive Assessment System (CAS) applicable to children up to the age of 18. The CAS includes measures of attention (Expressive Attention, Number Detection, Receptive Attention), simultaneous processing (Matrices, Figure Memory, Verbal - Spatial Relations), successive processing (Word Series, Sentence Repetition, Sentence The question, Speech Rate), and planning (Number Matching, Planned Codes, Planned Connection).

Both test batteries have at least three major common points: (1) They relate intelligence with brain activity and in this regard represent neuropsychological orientation of intelligence scales; (2) they are based on Luria's theory about brain organization of cognition; and (3) they attempt to include those cognitive abilities associated with prefrontal functions (Luria's third functional unit; prefrontal or "executive" functions). In this regard, they recognize that executive functions must be regarded as crucial elements of intelligent behavior.

Limitations of intelligence construct while assessing the cognitive functions

There are two different sets of instruments directed to the appraisal of cognitive abilities: the psychometric test of intelligence (WAPIS, WAIS) and neuropsychological assessment tests (e.g. Luria - Nebraksa neuropsychological battery, PGI-BBD etc).

The arguments here are that psychometric tests of intelligence services to assess the level of intelligence of to normal populations, whereas neuropsychological instruments serve to assess the cognitive function of brain - damaged population. Though neither is the exact answer. Psychometric tests of intelligence are frequently included in the neuropsychological assessment of the cognitive function of the population suffering from brain - damaged. In this course Wechsler Intelligence Scale adapted for the neuropsychological purpose has been developed (WAISR - NI; Kaplan., *et al.* 1991). At the same time, neuropsychological instruments are frequently used for both, the population suffering from brain damage and for normal populations.

Another debate is that executive function (i.e., "frontal lobe" capacities), memory and visuospatial capacities are contributory domains of knowledge. In contemporary neuropsychology, these abilities signify the important cognitive abilities, and the psychometric instrument to assess the intelligence does not assess some of these abilities.

There is another discussion that there is no enough scientific rationale for including subtests in current intelligence batteries. The knowledge about the brain sciences has progressed mostly in the last 50 years. The popularly adopted intelligence test like WAIS is nearly three-quarters of a century ago.

Possibilities of including cognitive functions while assessing intelligence

The concept and interpretation of intelligence continue to be controversial. Neisser., et al. (1996) recognized that there are different ways to interpret intelligence. No single interpretation of intelligence testing data is widely accepted.

Many factors may be simultaneously acting on the scores obtained in intelligence tests: genetic factors, some early biological conditions, environmental factors, cultural values, etc.

Since Thurnstone [9,10], there is the converging consensus that some fundamental cognitive abilities may be distinguished. Researchers refer to a limited number of domains, usually six to nine, frequently appearing in factor analytic studies of psychological [27] and neuropsychological test batteries [28-30]. In the same way Gardner [17] when he proposed different types of intelligence.

There are no fixed tests to evaluate these domains, even though some tests may be better, at least at a certain historical moment. In the future, new and better tests can be developed to appraise these domains, and these domains may even be restated and rearranged.

In neuropsychology, there are several tests that have become widely accepted and extensively used [31,32]. They are considered reliable, sensitive, and in general "good" tests. There is a significant research body supporting their reliability and validity. An evaluation of cognitive abilities should include these widely accepted tests.

As a matter of fact, many of them have been taken from the intelligence testing research, and in this regard, psychometric intelligence testing and neuropsychological testing may be complementary rather than mutually exclusive. It is expected that in the future, superior testing instruments will be developed, replacing the current tests that now are considered the best available neuropsychological instruments. Examples of these cognitive domains, and potentially useful tests are:

Cognitive Domains	Assessed functions	Examples of related tests
Attention	Focused attention	Digits backwards
	Sustained attention	Serial subtractions etc.
Language	Verbal fluency	Using semantic and phonological categories
	Language comprehension	Token test
	Lexical knowledge	(naming, vocabulary, or other similar test sv)
Calculation abilities	Arithmetical operations	
	Numerical problems	
Perceptual abilities	Visual recognition of figures under different conditions	Visual detection, to recognize embedded or unusually presented figures, to find similarities and differences between figures, etc.
	Recognition of sounds and music	Verbal-phonological discrimination; and non-verbal rhythms, melodies, music, etc.
Memory and learning	Verbal learning	Serial Verbal Learning, California
	Verbal Learning Test	Rey Auditory Verbal Learning test, Logical Memory, etc
	Nonverbal learning	Benton Visual Retention test, immediate and delayed recall of figures
Visuo-constructive and visuospatial abilities	Visuo-constructive	Rey-Osterrieth Complex Figure
	Tests for spatial abilities	Such as line orientation
Motor	Fine movements	Such as the Finger Tapping Test or other fine movements test
	Praxis ability tests	
Executive function abilities	Abstraction	Similarities
	Reasoning	Raven Progressive Matrixes
	Concept formation tests	The Category Test, Wisconsin Card Sorting Test, etc.
	Some tests directed to "maintain instructions"	Stroop test, Trial Making-Test FormB, Luria's opposite reactions, etc.

Table 1

Although these tests are not necessarily evaluating a single cognitive domain. Attention is required for an appropriate performance in any intellectual test. Calculation of abilities represents a rather complex and multifactorial ability. Verbal memory depends on language understanding. For example, phonological verbal fluency can be interpreted as an executive function test, whereas semantic verbal fluency is closer to a lexical knowledge test. Furthermore, all these tests are significantly influenced by education, age, and cultural background. Norms for different groups should be obtained. Although raw scores can be nonequivalent in different educational, cultural, and age groups, standard normalized scores are equivalent. Each group itself represents its own norm. Tests must be standardized and norms obtained not only for different age ranges but also for different educational and cultural groups. Otherwise, what is normal for one group might be interpreted as pathological for another. When a particular group outscores another, this simply means that wrong norms have been used.

Conclusion

Psychometric intelligence tests do not seem to measure what from a neuropsychological perspective. The concept of IQ might disappear. It is archaic, and theoretically remains a controversial concept. Subtests used to measure "intelligence" is inappropriate in the era where researches are highlighting hoe specific genes that have been identified to generate cellular properties associated with intelligence and may ultimately explain structure and function of the brain areas involved [33].

These researches indicates that cognitive evaluation need to rely on neuropsychological instruments instead of using psychometric intelligence tests. No clear rational for the selected subtests of psychometric intelligence is easily found. Whereas neuropsychological tests have a clear and overt rationale from the point of view of the brain organization of cognitive activity. As suggested by Alfredo Ardila [29] It would seem more appropriate to use standard scores (such as T, z, or percentiles) for the individual tests and cognitive domains, than using global intellectual scores (such as IQ).

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Conflict of Interest

There is no conflict of interest.

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