Neuropsychological assessment : An overview

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ABSTRACT

Man's interest in the relationship between the brain and behaviour extends back at least 2500 years. The study of brain behaviour relationship evolved with the development of a science of human behaviour based on the function of human brain, known as neuropsychology. Clinical neuropsychology in the 20th century showed a steady accumulation of clinical reports and research investigations that have gradually refined the theoretical positions. However, assessment relies heavily on the use of specific tests to investigate brain-behaviour relationships. There has been several specific standardized tests as well as test batteries developed across the globe. Current article has focused on different neuropsychological test batteries to evaluate individuals suspected of having brain dysfunction or damage.

INTRODUCTION

Neuropsychology is the study of brain-behaviour relationship with the development of a science of human behaviour based on the function of human brain. Clinical Neuropsychology is the application of empirically established facts concerning brain-behaviour relationships to clinical problems and neurological assessment, which is sensitive to the condition of the brain. Man's interest in this area extends back at least 2500 years, when Pythagoras argued that the brain was the site of human reasoning. Approximately 100 years later, Hippocrates claimed that the brain was the organ of the intellect and recognized that a depressed skull fracture on the right side of the head could produce motor paralysis on the (contra lateral) left side of the body. Galen, in approximately 170 a.d., was able to map out many of the major brain structures and argued that the frontal lobes were the seat of our mental abilities. Galen's hypothesis, however, was later discarded in favour of the belief that reasoning and intelligence was a product of the ventricles of the brain.

It was not until 15 centuries later that Galen's views of the relationship between the cortex and intelligence were taken seriously, when Vesalius reported an anatomical relationship between the brain and intellectual functioning. He argued that humans are more intelligent than animals, because humans have larger brains. Present views on brain-behavior relationships began to take form since nineteenth century. During the last 20 years there has been a growing realization that the emotional and behavioural problems that accompany brain insults are more disabling than the cognitive problems that are produced (Lezak, 1987; Sbordone, 1990).

Neuropsychology can be divided into two branches. The first, clinical neuropsychology includes behavioural neurology and deals with patients with cerebral lesions. The second branch is experimental neuropsychology, which studies normal subjects in the laboratory by a range of techniques including specialized physiological techniques (Sbordone, Saul, & Purisch, 2007).

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NEUROPSYCHOLOGICAL ASSESSMENT : THE PAST

The use of psychological tests to investigate the behavioural consequences of brain damage was first utilized approximately 70 years ago in the United States. A number of publications appeared during the 1930s and 1940s that described the effects of frontal lobe lesions on intelligence and other functions, visual-spatial impairments following right frontal lobe lesions and the effect of brain damage on abstract thinking, and memory impairments following focal brain lesions (Jones & Butters, 1983). In the Soviet Union during this same time, Luria utilized psychological tests to investigate the effects of brain trauma and disease (Sbordone, Saul, & Purisch, 2007).

The first neuropsychological laboratory in the United States was set up by Ward C. Halstead in 1935. He used neuropsychological tests to study the effects of brain damage on a wide range of cognitive, perceptual, and sensory motor functions. In 1951, Halstead collaborated with his former student, Ralph M. Reitan, who had established a neuropsychology laboratory at Indiana University Medical Centre. Reitan (1955) modified Halstead's neuropsychological battery and created what is now described as the "Halstead-Reitan Battery." Reitan administered this battery to a number of patients with documented focal and diffuse brain damage, as well as to a group of hospitalized control patients, presumably free of brain disease, and developed a set of test norms. Indices developed by Reitan allowed him to localize brain damaged areas, as well as to infer the cause of the neurological injury (Wheeler, Burke, & Reitan, 1963).

Brenda Milner and her colleagues at the Montreal Neurological Institute and at McGill University have utilized neuropsychological assessment techniques to evaluate behavioural changes. Those patients have undergone the surgical removal of portions of their temporal lobes, which were believed to cause uncontrollable seizures. She described the relationships between verbal and nonverbal learning following temporal lobe lesions. She found that patients whose surgery involved the left temporal lobe had impaired verbal learning skills, while the patients who underwent right temporal lobe surgery had impaired visual learning skills (Milner,

1970). She also found that bilateral removal of the hippocampi produced a severe and permanent impairment in the ability to learn new information. On the basis of the research studies of Milner and her colleagues, a number of neuropsychological tests were developed that were particularly sensitive to damage to specific areas of the brain.

Hans-Lukas Teuber, at the Massachusetts Institute of Technology, used neuropsychological tests to study the effects of local brain damage on a variety of visual and spatial skills and identified the importance of the parietal lobes in spatial relations and the role of the frontal lobes in problem solving. These studies led to the development of several psychological tests that were found to be highly sensitive to specific brain lesions and the functions served by these regions (Teuber, 1972).

The Boston V.A. Medical Centre, under the leadership of Harold Goodglass, Edith Kaplan, and Nelson Butters, was responsible for the development of a number of neuropsychological tests based upon numerous research studies, which were conducted over a period of over 30 years. They assessed patients with aphasia, amnesia, and dementia, and developed "qualitative" methods for analyzing the various psychological and behavioural manifestations and damage to specific parts of the brain. Their approach has provided clinical neuropsychologists with a greater appreciation of the specific effects that brain damage can have on the individual. Arthur Benton, at the University of Iowa, also developed several neuropsychological tests and made a number of important contributions to clinical neuropsychology.

Alexander Luria, who was initially trained as a cognitive psychologist and then later as a physician and neurologist, spent over 40 years in studying the behavioural and psychological impairments of head-injured war victims and neurological and neurosurgical patients, and developed understanding about the relationship between a specific area of the brain and its effect on complex behaviours. He developed neuropsychological tests that could be administered at the patient's bedside and formulated a theory of brain-behavior relationships. His theory emphasized that complex behavior could be broken down into their respective components and studied separately to determine

which aspects of a “functional system” had been compromised. His evaluation procedure heavily emphasized qualitative methods based upon observation of the types of errors made by the patient.

Through collaboration with Anna-Lise Christensen, a Danish psychologist, Luria’s tests and method of neuropsychological assessment were introduced in the United States in 1975 under the title of Luria’s Neuropsychological Investigation. Unfortunately, it was generally not well received in the United States since it required the neuropsychologist to have extensive training and a strong background in behavioural neurology. In an attempt to rectify this, Charles Golden, Thomas Hammeke, and Arnold Purisch administered the several hundred test items contained in Luria’s Neuropsychological Investigation to normal controls and later to neurological patients. They utilized discriminant function statistical analysis techniques to determine which test items were sensitive to the presence of brain damage. Their research (Golden et al., 1978) resulted in a battery of 269 items, which could be administered to a patient in 2 or 3 hours. This test battery was eventually named the Luria-Nebraska Neuropsychological Battery and first introduced in 1978.

Within the past 20 years, there is an increased need to examine patients who had sustained traumatic brain damage in motor vehicle or road traffic accidents and to predict whether these patients could return to work, school, or their pre-injury duties and responsibilities. Unfortunately, the neuropsychological tests were never designed to make such predictions rather these tests were primarily developed to determine if the patient had brain damage and how it affected the patient’s cognitive functioning (Sbordone, Saul, & Purisch, 2007). Hence, this upcoming need forced neuropsychologists to focus on the ecological validity of the test data and how well are the tests able to predict a patient’s ability to function in real-world settings (Sbordone, 1997; Sbordone & Guilmette, 1999). Neuropsychological testing is primarily used today to determine whether a patient has sustained

brain damage when the neurological examination is normal, and the neuroimaging studies are negative. This is likely to place more emphasis on the development of innovative methods of assessing how the brain injury or dysfunction effects the patient’s functioning in real-world situations.

ASSESSMENT PROCESSES

Assessment process typically includes identifying specific areas of the brain, that have been damaged and demonstrating the relative severity of the patient’s cognitive and emotional impairments. Since, the issue of causation is often important, it is essential that a variety of confounding or extraneous factors be ruled out so that the relationship between a specific event (e.g., accident, trauma, or fall) and the patient’s neuropsychological impairments may be made as unequivocally clear as possible. Hence, primary goals of all neuropsychological evaluations are, first, to determine an individual’s cognitive and behavioural strengths and weaknesses, second, to interpret the findings from a diagnostic viewpoint, and third, to recommend viable treatment and rehabilitation resolutions (La Rue, 1992). Neuropsychological procedures also provide a complement to other medical evaluations when used in conjunction with quantitative or functional neuroimaging. This enhances the understanding of pathological disturbances of the brain (Howieson & Lezak, 2000).

There are two distinct strategies of approaching neuropsychological assessment, one is the comprehensive battery approach (also known as the fixed approach), and the other is flexible approach, utilizing a qualitative, hypothesis-testing strategy (Groth-Marnat, 2003). Each of these approaches has different strengths and weaknesses (Bauer, 2000; Jarvis & Barth, 1994; Russell, 2000). The advantages of the fixed approaches are, first, it assesses both strengths and weaknesses for a broad spectrum of behaviours, and second, it is more extensively normed and researched and has been validated psychometrically to identify individuals with brain damage. However, major disadvantages are, it is time consuming and may overlook the underlying reason for a client’s specific test score. It is also difficult to tailor toward the unique aspects of the client

and referral question. On the other hand, flexible approach is hypothesis-testing approach and can be tailored to the specifics of the client and referral question. It emphasizes the processes underlying a client's performance rather than a final score, is time efficient. It also allows the measurements of a client's strengths, weaknesses, or certain reasons for ambiguous responses to be pursued in depth. The major disadvantages of the flexible approach are that it focuses on a client's weaknesses, and relies too extensively on clinician's expertise. This approach consists of tests that have usually not been validated psychometrically to identify individuals with brain damage, and provides a narrower slice of a client's domains of functioning.

NEUROPSYCHOLOGICAL TEST BATTERIES

There are number of standardized neuropsychological batteries to evaluate individuals suspected of having brain dysfunction or damage. Some of the important neuropsychological test batteries are discussed below :

HALSTEAD-REITAN NEUROPSYCHOLOGICAL TEST BATTERY

This is perhaps the best known and most widely used battery, developed by Ward Halstead and Ralph M. Reitan (Horton & Wedding, 1984). The tests were initially used by Halstead to investigate the cognitive abilities that were compromised by brain injury. It consists of adult, intermediate child (9 to 14 years) and young child (5 to 8 years) versions. Each battery is designed to include a minimum of 14 neuropsychological tests capable of assessing as many as 26 different brain-behavior relationships. The Halstead-Reitan Battery includes Aphasia Screening Test (Halstead & Wepman, 1959), Halstead Category Test (Reitan & Wolfson, 1993), Finger Tapping Test (Halstead, 1947; Reitan and Wolfson, 1993), Grip Strength (Hand Dynamometer) Test, several perceptual examinations, tactile and tactual perceptual examinations. This battery also includes Minnesota Multiphasic Personality

Inventory (MMPI) (Hathaway & McKinley, 1940), and Wechsler Adult Intelligence Scale (WAIS) (Wechsler, 1955). The indices include Halstead Impairment Index, Average Impairment Index, and General Neuropsychological Deficits Scale.

LURIA-NEBRASKA NEUROPSYCHOLOGICAL BATTERY (LNNB)

It is a comprehensive battery that integrates the neuropsychological assessment procedures of the late Professor Alexander Romanovich Luria and the American psychometric tradition through the work of its authors (Golden et al., 1978). This battery contains a total of 269 test items that make up 11 clinical scales, which are motor functions, rhythm and pitch, tactile and kinaesthetic functions, visual functions, receptive language, expressive language, reading, writing, arithmetic, memory, and intellectual processes. Later on Form II was developed, which is "largely a parallel form". This contains a 12th scale, intermediate memory, which assesses delayed recall of some of the previously administered short-term memory items.

Performance on each item is evaluated on a 3-point scale where, 0 indicates no impairment and 2 indicates severe impairment. The summed scores for each of these scales produce 11 of the above scoring indices.

In addition to these scales, 3 additional scales have been developed (based on the 269 test items) that are sensitive to brain impairment and recovery following brain injury. These are known as the Pathognomonic, which consists of items that best discriminated patients with brain impairment from healthy controls and sensitive to the acuteness of an injury, Profile elevation, and Impairment scales together register the level of present functioning and degree of overall impairment. LNNB also contains 2 lateralization scales, i.e., left-hemisphere and right-hemisphere scale, which are composed of all the tactile and motor function items.

In addition, 8 scales (four for each side of the brain) have been developed to localize brain damage to the frontal, sensorimotor, parietal-occipital, and temporal regions. Also attempts to integrate the qualitative tradition of Luria by listing 66 different qualitative indices that aid the examiner in evaluating the nature of failure and not merely its fact. The entire test battery can usually be administered in 2½ to 3 hours.

Unlike the Halstead-Reitan, the Luria-Nebraska is portable and can be administered at the patient's bedside. It is designed to be administered to patients 14 years and older.

Children revision (Golden, 1989) of this test is also available, which is a downward extension of the adult version for children in the age range of 8 - 12 years consisting of 11 subscales discussed above.

NEUROPSYCHOLOGICAL ASSESSMENT BATTERY (NAB)

This was designed by Stern and White (2003) to assess the major five cognitive areas (called "modules") of functioning, i.e., Attention, Language, Memory, Spatial, and Executive functions. A sixth module called the screening module is composed of two or more of the same or abbreviated tests in the other five modules so chosen as to test both high and low ability levels. The battery was developed for flexible use. Each module (including the screening module) can stand alone and norms are provided for individual tests as well.

SAN DIEGO NEUROPSYCHOLOGICAL TEST BATTERY

It was developed as part of a Multicentre National Traumatic Coma Data Bank Program to provide a complete mental status examination by Baser and Ruff (1987). The goal was not necessarily to develop new tests, but rather to use tests that had psychometric properties. The time for test administration was limited to an average of 3½ hours to avoid excessive fatigue or the need to split testing over two sessions. The underlying theoretical basis of this test is Luria's

three primary functional units (arousal, analyzing and coding, and planning). This battery consists of 21 procedures that together yield a total of 38 scores. The test data is initially interpreted quantitatively in terms of whether a patient's performance falls in the normal, borderline, or impaired range on each of the 38 test scores. These test scores are then qualitatively evaluated based on Luria's model of cortical organization.

MICROCOG ASSESSMENT OF COGNITIVE FUNCTIONING COMPUTERIZED BATTERY

It is a computer-administered and scored test that was intended to serve as a screening device or diagnostic tool as part of a general neuropsychological examination or examination of cognitive functioning (Powell et al., 1993). The standard form consists of 18 subtests and the short form contains 12 subtests. Nine index scores are derived from the subtest scores and are conceptually formed to represent functioning in five neuro-cognitive domains, i.e., attention/mental control, memory, reasoning/calculation, spatial processing, and reaction time. Interpretation of the patient's test data is generally based on level of performance in comparison to an appropriate normative group. The Microcog automatically computes a number of pairwise comparisons between index scores and subtest scores. These comparisons were selected on the basis that significant differences between them would most likely be clinically meaningful. In general, the larger the discrepancy and the less frequently it occurs, the less likely it can be explained as a normal variation.

NEPSY : A DEVELOPMENTAL NEUROPSYCHOLOGICAL ASSESSMENT TEST TO ASSESS YOUNG AND OLDER CHILDREN

The NEPSY was designed to detect subtle cognitive deficits that can interfere with the ability of a child to learn new information, to detect and describe the effects of brain damage or dysfunction in young children, following-up children with brain damage and dysfunction to determine whether any recovery or improvement has been made, and providing

valid test results to assess the neuropsychological development of children (Korkman et al., 1998). This test incorporates Luria's neuropsychological approach with Developmental Neuropsychology. It was designed to function as a flexible test battery. It contains five core cognitive domains as well as expanded and supplemental subtests, which can be selectively administered based on the reason for the assessment being performed and the specific characteristics of the child. It does not yield an overall score, which is consistent with Luria's conceptual model of neuropsychological functioning as composed of independent but related functional systems (Strauss et al., 2006). The five core domains include attention/executive functions, language, sensory or motor function, visual spatial processing, and memory and learning.

Two versions of the test can be utilized depending on the age of the child. The battery is designed to assess children who range from 3 to 12 years of age. Children ranging in age from 3 to 4 are given a different test battery than children whose ages range from 5 to 12. The addition of supplemental neuropsychological tests allows a more complete interpretation of the significance of a child's scores in these cognitive domains. It also utilizes a qualitative assessment of the child's behavior during testing and allows the examiner to perform a complex multidimensional assessment that can be customized to meet the specific needs of the individual child (Kemp et al., 2001).

BATTERIES DEVELOPED IN INDIA

Indian population has wide variations with reference to age, socio-cultural aspects, education and test taking attitude. Hence normative data collected elsewhere will not be true representation in Indian context. Although the field of neuropsychology in the international context has seen the development of many tests in the recent past, these tests cannot be used in our country without being modified. Also some words used in a test may not carry meaning to Indian population. There are a handful of test batteries/developed and/or standardized in India. Those are discussed below :

PGI BATTERY OF BRAIN DYSFUNCTION (PGIBBD)

This test battery attempts to evolve a psychometric profile that can differentiate patients of organic brain dysfunction from those having no organic pathology, by Pershad and Verma (1990). The PGI-BBD was standardized on adult males and females, both for literate and illiterate in the age range of 20 to 45. However, this test can be used on subjects up to 50 years of age. The battery measures the well known cognitive functions namely intelligence (both verbal and performance), memory, perceptual acuity, and transference from one hemisphere to another.

PGI-BBD is based on the assumption of functional unity of the brain as a whole. It thus measures the functioning of the brain. It is not purported to be used for brain pathology lateralization or localization of the hemispheric functions. It consists of PGI-Memory Scale, Battery of Performance Tests of Intelligence, Verbal Adult Intelligence Scale, Nahor-Benson Test, and Bender Visual-Motor Gestalt Test. It can be used to rule out or confirm the presence of organic brain pathology. However, definite locations and size of the lesion cannot be measured by this test. Further, the test is not very useful for making a neurological diagnosis.

AIIMS COMPREHENSIVE NEUROPSYCHOLOGICAL BATTERY IN HINDI

This test battery has been constructed using Luria's neurological approach for understanding brain-behaviour relationships. This can be administered on adults as well as on children. The adult battery can identify brain dysfunction in neurologic patients with success rates of more than 80%. Whenever the patient is diagnosed as having a brain dysfunction, the battery can identify a right/left/diffuse brain dysfunction with over 90% success rate.

The test consists of 160 items in Hindi spread over 10 basic scales. A 5-point scale for each item was developed for evaluating performance in order

to enhance the precision of the battery. A score of 0 (zero) is given for passing the item successfully. And a score of 4 is given for complete failure on the item. Credits of 1, 2 and 3 are given to intermediate performances. Primary scales in this battery include Motor, Tactile, Visual, Receptive and Expressive Speech, Reading, Writing, Arithmetic, Memory, and Intellectual Processes Scale. Out of these basic content scales, 3 other scales i.e. pathognomonic, left hemisphere, and right hemisphere scales were also derived. The format allows for the design of specific scales identified for picking up damage in each localized area of the brain. Interpretation can be made in terms of presence of brain dysfunction in terms of lateralized, localized, and diffused.

The child version was developed and standardized to facilitate discrimination between brain damaged and normal children and also to provide a basis to discriminate children with lateralized brain damage. This battery is based upon Luria's procedures and has been shown to be effective in discriminating brain injured patients from psychiatric and normal subjects.

NIMHANS NEUROPSYCHOLOGY BATTERY

This is developed by Rao, Subbakrishna, & Gopukumar (2004) to collect normative data for 19 widely used tests for Indian population which assess various domains, and are in current international usage. The tests are: Tests of speed which include Finger Tapping Test (motor speed), Digit Symbol Substitution Test (mental speed) (Wechsler, 1981), tests of attention include Colour Trails Test (focused attention), Digit Vigilance Test (sustained attention), and Triads Test (divided attention). Token Test (De Renzi & Vignolo, 1962) is used to assess comprehension, i.e., the ability to understand spoken speech. Rey's Auditory Verbal Learning Test (AVLT) (Schmidt, 1996) is used to assess verbal learning and memory, and immediate and delayed recall of a meaningful passage is used to assess logical memory. Visuoconstructive ability is assessed

by Rey's Complex Figure Test (Myers & Myers, 1995), visual learning and memory, and Design Learning Test (Jones - Gottman et al., 1997). This battery puts emphasis on executive functions and includes fluency test, working memory (both verbal and visual), planning, set shifting, and response inhibition. Assessment yields a neuropsychological profile in terms of the deficits and adequacies in the different neuropsychological domains of functioning.

The child battery was developed by Kar, Rao, Chandramouli, & Thennarasu (2004) and designed with a careful consideration for the developmental perspective in child neuropsychological assessment. It covers the whole paediatric age range (5 - 15 years of age) for its wider application and is sensitive to the developmental perspective of child neuropsychological assessment. This also gives an opportunity to study the growth profile across the age levels. Each test included assesses a known specific function and has well-established construct validity. The battery has been standardized on Indian children. The norms are based on the empirical validation of age trends of neuropsychological functions using the growth model approach. The battery is sensitive to the effects of brain damage and has been validated in terms of localization and lateralization of brain dysfunction.

CONCLUSION AND FUTURE DIRECTIONS

Current neuropsychological assessment procedures represent a technology that has barely changed since the first scales were developed in the early 1900s. Recent developments in computing technology have many advantages over traditional paper and pencil tests in terms of precision, speed and reliability.

The University of Cambridge in the 1980s developed the Neuropsychological Test Automated Battery (CANTAB) with a view to utilizing the advantages of computerized testing. It is designed to test different aspects of mental functioning and a profile of performance for a particular patient group. It

employs non-verbal stimuli and requires nonverbal responses, which is essential for patients with language impairment.

With the advent of neuroimaging, the role of neuropsychology has shifted to documentation of neuropsychological deficits for prediction of real world functioning. The future of neuropsychological assessment appears to be headed towards the development of assessment techniques that will combine the control and rigor of technologically advanced computerized laboratory measures, the psychometric rigour of traditional paper-and-pencil assessments and strong ecological validity.

REFERENCES

1. Baser, C.A. and Ruff, R.M. 1987. Construct Validity of the San Diego Neuropsychological Test Battery. *Archives of Clinical Neuropsychology*, 2, 13-32.
2. Bauer, R.M. (2000). The flexible battery approach to neuropsychological assessment. In R.D. Vanderploeg (Ed.), *Clinician's guide to neuropsychological assessment* (2nd ed., pp. 419-448). Hillsdale, NJ : Earlbaum.
3. De Renzi, E. & Vignolo, L.A. (1962). The Token test : a sensitive test to detect disturbance in aphasics. *Brain*, 84, 665-678.
4. Golden, C.J., Hammeke, T.A., and Purisch, A.D. (1978). Diagnostic Validity europsychological Battery Derived from Luria's Neuropsychological Tests. *Journal of Consulting and Clinical Psychology*, 46, 1258-1265.
5. Golden, C.J. (1989). The Luria Nebraska Neuropsychological Children's Battery. In C.R. Reynolds & E. Fletcher-Janzen (Eds.), *Handbook of Clinical Child Neuropsychology* (pp. 93 - 204). New York & London : Plenum Press.
6. Groth-Marnat, G. (2003). *Handbook of psychological assessment* (4th Ed.). New York : John Wiley & Sons.
7. Halstead, W.C. & Wepman, J.M. (1959). The Halstead Wepman Aphasia Screening Test. *Journal of Speech and Hearing Disorders*, 14, 9-15.
8. Halstead, W.C. (1947). *Brain and Intelligence*. Chicago : University of Chicago Press.
9. Hathaway, S.R. & McKinley, J.C. (1940). A Multiphasic Personality Schedule (Minnesota). I : Construction of the schedule. *Journal of Psychology*, 10, 249-254.
10. Howieson, D.B., Lezak, M.D. (2000). The neuropsychological evaluation, in the *American psychiatric Textbook of Neuropsychiatry and Clinical Neurosciences*, 4th Edition. Edited by Yudofsky, S.C., Hales, R.E. Washington, DC, American Psychiatric Press, pp. 217-244.
11. Jarvis, P.E. & Barth, J. (1994). *The Halstead-Reitan Neuropsychological Battery : A guide to interpretation and clinical application*. Odessa, FL : Psychological Assessment Resources.
12. Jones, B.P. and Butters, N. (1983). Neuropsychological Assessment. In Hersen, M., Kazdin, A. E., and Bellack, A. S. (Eds.). *The Clinical Psychology Handbook*. New York : Pergamon Press, pp. 377-396.
13. Jones-Gotman, M., Zatorre, R.J., Olovier, A., Andermann, F., Cendes, F., Staunton, H., McMackin, D., Siegel, A.M., & Wieser, H.G. (1997). Learning and retention of words and designs following excision from medial or lateral temporal lobe structures. *Neuropsychologia*, 35, 936-973.
14. Kar, B.R., Rao, S.L., Chandramouli, B.A., Thennarasu, K. (2004). *NIMHANS Neuropsychological Battery for Children Manual*. Bangalore : National Institute of Mental Health and Neurosciences.
15. Kemp, S.L., Kirk, U., and Korkman, M. 2001. *Essentials of the Nepsy Assessment*. New York : John Wiley & Sons, Inc.
16. Korkman, M., Kirk, U., and Kemp, S. 1998. *Nepsy a Developmental Neuropsychological Assessment Manual*. San Antonio, TX : The Psychological Corporation.
17. La Rue, A. (1992). *Aging and neuropsychological assessment*. New York, Plenum.
18. Lezak, M.D. (1987). Relationships between Personality Disorders, Social Disturbances and Physical Disability Following Traumatic Brain Injury. *Journal of Head Trauma Rehabilitation*, 2, 57-69.
19. Meyers, J. & Meyers, K. (1995). *Rey Complex Figure and Recognition Trial : professional manual*. Florida: Psychological Assessment Resources.
20. Milner, B. (1970). Memory and the Medial Temporal Regions of the Brain. In Pribram, K. H. and Broadbent, D. E. (Eds.) *Biology of Memory*. New York : Academic Press.
21. Pershad, D. & Verma, S.K. (1990). *Handbook of PGI battery of brain dysfunction (PGI-BBD)*. Agra, India : National Psychological Corporation.
22. Powell, D.H., Kaplan, E.F., Whitla, D., Weintraub, S., Catlin, R., and Funkenstein, H. H. 1993. *Microcog Assessment of Cognitive Functioning (Manual)*. San Antonio, TX : Psychological Corporation.
23. Rao, S.L., Subbakrishna, D.K., Gopukumar, K. (2004). *NIMHANS Neuropsychology Battery Manual*. Bangalore : National Institute of Mental Health and Neurosciences.
24. Reitan, R.M. & Wolfson, D. (1993). *The Halstead-Reitan Neuropsychological Test Battery : Theory and Clinical Application* (2nd Ed.). Tucson, AZ : Neuropsychology Press.
25. Reitan, R.M. (1955). The Distribution According to Age of a Psychological Measure Dependent upon Organic Brain Functions. *Journal of Gerontology*, 10, 338.
26. Russell, E.W. (2000). The cognitive-metric, fixed battery approach to neuropsychological assessment. In R.D. Vanderploeg (Ed.), *Clinician's guide to neuropsychological assessment* (2nd ed., pp. 449-483). Hillsdale, NJ : Earlbaum.

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27. Sbordone, R.J. (1990). Psychotherapeutic Treatment of the Client with Traumatic Brain Injury. In Kreutzer, J.S. and Wehman, P. (Eds.) *Community Integration Following Traumatic Brain Injury*. Baltimore : Brookes, pp. 139-156.
28. Sbordone, R.J. (1997). The Ecological Validity of Neuropsychological Testing. In Horton, Jr., A.M., Wedding, D., and Webster, J. (Eds.). *The Neuropsychology Handbook* (Vol. 1), 2nd Ed. New York : Springer, pp. 365-392.
29. Sbordone, R.J. and Guilmette, T.J. 1999. Ecological Validity : A Prediction of Everyday and Vocational Functioning from Neuropsychological Test Data. In Sweet, J.J. (Ed.) *Forensic Neuropsychology Fundamentals and Practice*. Lisse, Netherlands : Swets & Zeitlinger, pp. 227-254.
30. Sbordone, R.J., Saul, R.E. & Purisch, A.D. (2007). *Neuropsychology for psychologists, health care professionals and attorneys* (3rd Ed.). Boca Raton, Florida : CRC Press
31. Schmidt, M. (1996). *Rey Auditory Verbal Learning Test : a handbook*. Los Angeles : Western Psychological Services.
32. Stern, R.A. and White, T. 2003. *Neuropsychological Assessment Battery Administration, Scoring, and Interpretation Manual*. Lutz, FL : Psychological Assessment Resources.
33. Strauss, E., Sherman, E.M. S., and Spreen, O. 2006. *A Compendium of Neuropsychological Tests*, 3d ed. New York : Oxford Press
34. Teuber, H.L. (1972). Unity and Diversity of Frontal Lobe Functions. *ACTA Neurobiologica Experimentalis*, 32, 615-656.
35. Wechsler, D. (1955). *Manual for the Wechsler Adult Intelligence Scale*. New York : Psychological Corporation.
36. Wechsler, D. (1981). *WAIS-R manual*. New York : The Psychological Corporation.
37. Wheeler, L., Burke, C.H., and Reitan, R.M. (1963). An Application of Discriminant Functions to the Problems of Predicting Brain Damage Using Behavioral Variables. *Perceptual and Motor Skills*, 16, 417.