

Neuropsychology for Neurologists

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INTRODUCTION

Neuropsychological evaluation is an important adjunct in the evaluation of selected neurologic patients. It serves as an extension of the mental status examination, and employs standardized measures to evaluate performance relative to the entire population or to specialized subpopulations (e.g., patients with less than a high school education). Neuropsychological evaluation allows for a qualitative interpretation of problem solving strategies in addition to the quantitative results. However, neuropsychological evaluation is not appropriate for all patients with cerebral disease or even all patients with impaired cognitive functioning. Variability also exists in the training and experience of psychologists performing neuropsychological testing, which may effect the validity and reliability of the neuropsychological findings. In this seminar, we will examine common approaches to neuropsychological assessment, training issues, and use and misuse of neuropsychological tests. Pediatric neuropsychology, including assessment of learning disabilities, will not be discussed.

BACKGROUND

For many years, the Halstead-Reitan Battery was synonymous with neuropsychological testing in the United States. The Halstead-Reitan battery consists of a series of tests chosen by Ward Halstead at the University of Chicago in the 1930s to investigate the effects of brain injury on cognitive abilities. These tests were subsequently applied to different clinical populations in the 1950s by Ralph Reitan to assist with the detection of brain damage or "organicity." The Halstead-Reitan Battery consists of the Category Test, Tactual Performance Test, Seashore Rhythm Tests, Speech Sounds Perception Tests, Finger Tapping Test, and Trail Making. With this approach, performance is classified as normal or impaired for each test. Based upon the proportion of tests passed and failed (i.e., Halstead Impairment Index), the patient is considered either normal or brain impaired. In addition to the above tests, the Aphasia Screening Test, a Sensory-Perceptual Examination, and grip strength have been added although performance on these tests is not considered in the Impairment Index.

Although many neuropsychologists still administer the Halstead-Reitan battery, a gradual shift away from this test battery has occurred since the role of neuropsychological assessment in most contexts is no longer to detect "organicity," but rather, to assess the cognitive and behavioral deficits associated with known cerebral lesions. Many neuropsychologists, however, continue to use selected tests from the Halstead-Reitan Battery in their clinical evaluations.

Despite neuropsychology's diminished role in the detection and localization of cerebral lesions, most neuropsychological batteries are constructed to assess standard neurobehavioral aspects of brain impairment associated with focal brain lesions or obtained through the study of patients with traditional neurobehavioral

syndromes. The areas most commonly assessed include general intellectual function (i.e., IQ), language, visual spatial ability, memory and learning, attention and concentration, motor/sensory function, abstraction and executive function, and personality. A comprehensive listing and description of specific tests that may be used in neuropsychological assessment can be found in Lezak (1995).

NEUROPSYCHOLOGICAL ASSESSMENT TESTS AND PROCEDURES

Most neuropsychologists obtain standard intellectual measures including Full Scale IQ, Verbal IQ, and Performance IQ. In adults, the most commonly employed intelligence test is the Wechsler Adult Intelligence Scale-Revised (WAIS-R). The three summary IQ measures are derived from averaging individual subtest scores. Thus, unless diffuse decline in cognitive abilities exists (e.g., dementia or head injury), the usefulness of the summary measures is limited (Lezak, 1988). Nevertheless, by tradition if nothing else, these scores are dutifully reported in the neuropsychological report. Of more interest is specific IQ subtest performance, and most neuropsychologists interpret tests scores with non-IQ subtests measures of similar neuropsychological constructs (e.g., WAIS-R Block Design compared with the Rey-Osterrieth Complex Figure). Full Scale IQ measures are helpful in selected cases such as in head injury because, in addition to reflecting diffuse cognitive decline, they are familiar and many believe (erroneously) that they know what IQ scores mean. One major advantage of IQ tests is their large-scale formal standardization with excellent normative information.

Academic Achievement. Achievement testing usually consists of reading single words, spelling, and arithmetic. Achievement tests such as the Wide Range Achievement Tests (WRAT) are well standardized and provide good measures of scholastic attainment or accomplishment. However, the reading subtest requiring pronunciation of single words is often used to estimate premorbid level of function. As the test gets harder, words are presented than cannot be pronounced correctly based upon phonics (e.g., paradigm). Thus, correct pronunciation is taken as evidence of prior familiarity, and unless the patient is aphasic, provides one measure to estimate level of function prior to an accident or disease.

Other measures of academic achievement are more specialized and are commonly employed in school-aged children when learning disability or attention deficit disorders are being evaluated. These tests may include measures of reading comprehension for paragraphs, receptive vocabulary (e.g., point to the picture of an owl), or reading recognition.

Language. Language is commonly assessed with the Aphasia Screening Test of the Halstead-Reitan Battery. However, this test yields primarily qualitative information. It is frequently supplemented by examining generative verbal fluency (how many words can be generated beginning with either a particular letter of the alphabet or from a specific semantic category such as fruits and vegetables), confrontation naming (e.g., Boston Naming Test or Multilingual Aphasia Examination Visual Naming Test), or comprehension (e.g., Token Test). Comprehensive aphasia batteries such as the Boston Diagnostic Aphasia Examination, Multilingual Aphasia Examination, or Western Aphasia Battery are typically not administered unless there are specific questions regarding aphasia subtyping or the need to fully delineate language functioning exists.

Visual Spatial. Visual spatial ability is assessed with a variety of tests, the most familiar of which are the WAIS-R Block Design test and the Rey-Osterrieth Complex Figure. Although the Bender Gestalt test has been frequently used to assess visual motor function, it has been used less over the last decade, perhaps due to poor standardization and scoring criteria and the presence of newer tests of visual spatial function. Other commonly used tests include the Visual Retention Test, Judgement of Line Orientation and Facial Recognition Tests of Benton, and the Hooper Visual Organization Test.

Attention/Concentration. Attention and concentration can be measured with a variety of neuropsychological tests. From the Halstead-Reitan Battery, the Seashore Rhythm Test and Speech Sounds Perception Test are sensitive to attentional deficits. Many neuropsychologists continue to use these tests as measures of right and left temporal lobe function, but recent research from Reitan's laboratory shows that although both are good measures of attentional processes, they are poor measures of lateralized temporal lobe impairment (Reitan & Wolfson, 1989; Reitan & Wolfson, 1990). Trail Making A and B require the patient to connect either numbers, or alternate between numbers and letters (i.e., 1-A-2-B, etc.), distributed in a spatial array. Although Trail Making can be affected by visual spatial impairment due to a significant scanning component, the time to completion makes it also sensitive to attentional impairments. The task alternation aspect of Trail Making B makes it sensitive to certain aspects of executive/frontal lobe function.

Digit span from the WAIS-R (both forward and backward) is a good measure of gross attention, although vigilance tests (i.e., Continuous Performance Test in which the patient responds only when the letter "X" is flashed among a series in individually presented letters, or to respond only to the letter "X" if immediately preceded by the letter "A") and reaction time measures may be obtained when a more fine grained analysis is necessary. The Paced Auditory Serial Addition Tests (PASAT) is a measure of sustained attention, and requires the patient to add pairs of serially presented randomized number so that each number is added to the number immediately preceding it.

Memory and Learning. Memory is most often assessed using the Wechsler Memory Scale (WMS) or its revision (WMS-R). However, the WMS has been criticized on both methodological and theoretical grounds (Erickson and Scott, 1977; Loring and Papanicolaou, 1987). The WMS, published in 1945, yields a memory quotient, or MQ, that may be informally contrasted with a patient's IQ to suggest if a relative impairment exists in memory functioning. However, the individual subtests contributing to the MQ were not standardized, and several subtests contained constructs that, although necessary for successful memory performance, are not genuine measures of memory (e.g., Orientation and Mental Control). In addition, the WMS does not examine retention of information over time.

The most commonly employed WMS subtests that are individually administered include Logical Memory, Visual Reproduction, and Paired Associate Learning. Logical Memory is a test of paragraph or prose passage recall. Visual Reproduction examines immediate reproduction of simple geometric designs. Paired Associate Learning tests the ability to form associations between word pairs, some of which are easy (e.g., penny/quarter), and some of which are difficult (yield/page). When selected subtests are administered, a 30 minute delay component is often obtained (e.g., Russell, 1975). Significant limitations of the WMS include lack of adequate scoring criteria for memory units of the paragraph, and lack of adequate normative information.

The WMS was revised in 1987, and in addition to retaining the commonly employed subtests described above, added several new subtests although many problems associated with the test remain (Loring, 1989). Five summary measures are derived from performance on this test: General Memory, Verbal Memory, Visual Memory, Delayed Recall, and Attention Concentration. The WMS is now undergoing revision and restandardisation and will most likely be called the WMS-III.

The other major self contained standardized collection of memory subtests in the Memory Assessment Scales (Williams, 1990). The specific content of the items differs from the WMS-R, but it also yields summary measures for General Memory, Verbal Memory, and Visual Memory. It is less popular than the WMS-R, but in our experience at the Medical College of Georgia, it frequently provides lateralizing information in candidates for anterior temporal lobectomy.

Many neuropsychologists give word list learning tasks as additional measures of verbal memory. The most common word list learning tests are the Rey Auditory Verbal Learning Test, California Verbal Learning Test, and Buschke Selective Reminding Test. Visual memory is frequently assessed using the Rey-Osterrieth Complex Figure. However, the specificity of visual memory impairment to right temporal lobe dysfunction is much less than that associated with verbal memory deficits and left temporal lobe impairment. Although the Benton Visual Retention is sometimes employed as a visual memory test, it does not examine retention of material over long delays, and is generally considered as a test of visual construction or visual attention. The Memory Assessment Scale is a battery of tests similar in construction to the WMS, and yields a general memory measure in addition to verbal and visual memory summary scores.

Executive Function/"Frontal" Lobe Tests. Tests of executive function, informally called frontal lobe tests, most commonly include the Wisconsin Card Sorting Test (WCST) and Halstead Category Test. In the WCST, the subject is given a deck of cards that can be sorted into different categories based upon color, shape, and number. It is the subject's task to figure out how to sort the cards based solely on feedback from the examiner whether each response is "correct" or "incorrect." The Category Test is similar, although each stimulus represents a number from 1-4 and it is the patient's task to figure out what aspect of the stimulus is used for number representation. The only information given to the patient concerns the correctness of the response. Consequently, the patient must engage a series of hypotheses to learn the underlying principle. Tests of maze performance may also be used to assess planning and impulse control. Trail Making B is sensitive to task alternation difficulty (1-A-2-B).

Sensory and Motor Function. Tests of sensory and motor function are tested to varying degrees depending both upon the patient population and the biases of the examiner. Common tests of motor and fine motor function include the finger tapping and grooved pegboard tests. Grip strength is assessed with a hand dynamometer. Sensory testing may consist of measures of stereognosis from the Halstead-Reitan Battery, although this test is sensitive to inter-examiner variability. The Halstead-Reitan Battery tactual performance test requires the blindfolded patient to feel different shapes and to fit them into a formboard. However, many factors contribute to the tactual performance test (visual spatial ability, memory, motor function), making this test sensitive to brain impairment independent of its location.

Task Motivation/Test Validity. In patients with mild head injuries, neuropsychological test performance may be the only evidence of cerebral involvement. However, the neuropsychological evaluation is dependent on patient motivation and compliance, and consequently, not all performances in the "impaired" range reflect brain pathology. Although inclusion of explicit measures of task motivation and tests validity should be included in all neuropsychological assessments, it is particularly true when a strong financial incentive to perform poorly on neuropsychological tasks exists.

As with the neurologic evaluation, inconsistent performance may suggest malingering or, at least, failure to put forth one's best effort. However, other factors such as anxiety and fatigue may produce neuropsychological test inconsistencies. Measures of task motivation and test validity include clinical judgement based upon standard neuropsychological tests, validity measures from the MMPI, performance patterns present in existing neuropsychological testing, and formal measures designed explicitly to detect performance distortion (e.g., forced-choice symptom validity checking).

Clinical judgement may be used to infer less than maximum task performance (e.g., an IQ of 60 following a minor head injury with no loss of consciousness), although often clinical experience alone is not a good indicator of motivation (e.g., Heaton et

al., 1978). The MMPI contains explicit validity measures, and evidence on the MMPI suggesting that the patients are purposely presenting themselves poorly may be generalized to other test results.

Symptom Validity Memory Testing typically employs a forced choice recognition format for numbers (e.g., Hiscock & Hiscock, 1989). A series of digits is presented, typically on a computer screen. Following a delay ranging from a few seconds to as long as 30 seconds or more, two number sequences are presented from which the subject makes a selection. Feedback regarding correctness of response is given, and getting the correct answer at least half the time may make some patients get the impression that they are doing "too well" and begin purposely choosing the incorrect answer. Thus, performance of actively malingering patients may be below chance. As noted by Lezak (1995), the malingering patient may find it difficult to score within chance over many repeated trials.

Symptom validity testing results are unequivocal when the specific statistical probabilities of less than chance responding is obtained. Thus, the strongest evidence of malingering occurs when a patient scores significantly below chance, indicating that there has been a deliberate attempt to answer incorrectly. To score below chance, the patient must identify the correct answer and then choose the opposite and incorrect answer. That is, a patient must recognize the correct answer significantly above chance to score significantly below chance. Unfortunately, not all suspected malingerers perform worse than chance.

Simple "memory" tests are also frequently used. The most widely employed test in this approach is the 15 item (or 3x5) memory task described by Rey (in Lezak, 1995). The patient is presented with 15 items to "memorize," but in fact, due to immediate recall and the multiple redundancies in the stimuli, this is an extremely simple task. This technique relies on the examiner repeatedly informing the patient how hard the task is.

Personality. Most patients are administered some measure of personality function in addition to the tests of cognitive abilities. The most common approach is to use the MMPI/MMPI2, although some neuropsychologists may choose different inventories such as the MCMI/MCMI2. The need for measures of personality function is clear when performing an evaluation of possible dementia vs. depressive pseudodementia. However, personality testing is not used to determine the likelihood of cerebral compromise. Further, these inventories are unable to determine, for example, the amount of depression that is the primary result of cerebral injury vs. the amount that may be a psychological reaction to cerebral injury. Projective tests of personality are generally not employed in a neuropsychological context unless they are administered as part of a larger series of tests that includes objective measures such as the MMPI.

Personality assessment using the MMPI is frequently helpful in the evaluation of low back pain and in the prediction of outcome following back surgery. In addition, the MMPI may provide information regarding the personality contributions to medical disease including neurologic disease. Frequently, the neurologist may request personality assessment to help in the evaluation of back pain patients or to evaluate if a person's personality characteristics are significant clinical factors. When personality assessment is performed, it may be performed by clinical psychologists without specialized training and expertise in cognitive aspects of clinical neuropsychology. However, in certain cases of personality contributions to clinical complaints in patients with cerebral disease, background in neuropsychology is helpful in overall patient evaluation.

WHEN TO REFER FOR NEUROPSYCHOLOGICAL ASSESSMENT

Not all patients with cognitive or behavioral deficits from brain injury should be

referred for neuropsychological assessment. Although the threshold for each neurologist to make referral will be based in part on the experience and comfort with which they examine patients with neurobehavioral deficits, some guidelines are helpful in choosing which patients will benefit from neuropsychological assessment.

Patients who complain of cognitive deficits and have a normal or minimally impaired mental status examinations are frequently candidates for neuropsychological assessment. Neuropsychological testing is often most helpful when the deficits are mild. In cases of elderly patients who are experiencing normal age-related decline in mental status, neuropsychological testing may help to identify whether the subjective memory impairment is due to normal aging or may be related to early stages of a progressive dementia. Although neuropsychological testing cannot always help in the diagnosis of dementia during the earliest stages, it provides a reliable baseline against which subsequent evaluations can be compared to detect cognitive change. In addition, normal neuropsychological testing reassures elderly patients who are concerned that they may be developing Alzheimer's disease, and neuropsychological testing may be considered for certain cases in which cognitive decline is not suspected strictly to provide patient reassurance.

Not all cases of dementia or probable dementia require neuropsychological evaluation. Neurologists comfortable with dementia assessments may request neuropsychological evaluation only for unusual or atypical cases. However, neurologists whose practices encounter dementia cases less frequently may request neuropsychological assessment to make that diagnosis with greater confidence.

Patients with clear cognitive impairment may undergo neuropsychological evaluation, not for diagnostic consideration, but to help in competency issues such as driving, work, ability to manage funds, live independently, or to take medications. Similarly, patients with non-progressive neurologic disease may benefit from neuropsychological evaluation for management or rehabilitation issues, of assist in disability determination or readiness to return to work or school.

Patients with little formal education are frequently as difficult to assess with a battery of neuropsychological tests as they are with a bedside mental status evaluation and may not benefit from extended evaluation. A 75-year-old with two years of education and a lifelong history of manual labor may indeed have dementia, but it is a rare patient with this type background in which neuropsychological assessment provides information beyond that which can be obtained at the bedside. The norms that exist for patients with limited education simply do not exist, and the sensitivity of all neuropsychological tests is less at the low extreme of the distribution. Thus, neuropsychological testing, either with dementia rating scales (e.g., Mattis Dementia Rating Scale) or more traditional neuropsychological testing in these cases is used primarily for establishing a baseline to monitor disease progression.

STATISTICAL PROPERTIES OF TESTS

The best standardized tests, such as IQ tests, typically yield standardized scores that have a mean of 100 and a standard deviation of 15. Most neurologists are familiar with the general qualities of IQ scores such as mental retardation being labeled for IQs less than 70. As with any standardized distribution, about two-thirds of the population fall between -1 SD and +1 SD around the mean. With IQ scores, approximately two-thirds of the population has an IQ between 85 and 115. Approximately 95% of the population has an IQ that fall between -2 SD and + 2 SD (IQs between 70 and 130).

Because of these (and other) properties, the corresponding percentile difference between two IQ scores that differ by a fixed number of IQ points is not always the same. For example, an IQ of 75 corresponds to the 5th percentile, an IQ of 85

corresponds to the 16th percentile, an IQ of 95 corresponds to the 37th, and an IQ of 105 corresponds to a percentile of 63. Thus, the percentile difference for 10 IQ point change is 11 percentile points from IQs 75-85, 21 percentile points for IQs 85-95, and 26 percentile points for IQs 95-105. Similar relationships are present for other transformed scores such as scaled scores.

Norms for very old patients are limited. The WAIS-R provides norms only through age 74 years. There have been efforts by the Mayo clinic to obtain norms on healthy patients into the 90s (e.g., Ivnik et al., 1992), although this sample of subjects is better educated than average.

The sources of normative information also vary. Tests such as the Wechsler intelligence scales, Wechsler Memory Scale-Revised, Memory Assessment Scale, and Achievement tests have undergone formal standardization and have normative tables that are reliable and generally reflect the population at large. However, most other neuropsychological measures have not undergone formal standardization, and in consequence, the source of normative information is typically based upon published reports of healthy volunteers or control subjects and can be based on relatively few subjects. Many different sources of normative information exist for many commonly employed neuropsychological measure, and the choice among several normative tables is not necessary a trivial issue. Large discrepancies in interpretation may occur based upon the normative tables selected by the neuropsychologist for comparison. As pointed out by Van Gorp (1995), for example, a score of 28 seconds on Trail Making Part A in a 45-year-old patient with an 11th grade education may yield performances ranging from the 8th percentile (Bornstein, 1985) to the 75th percentile (Davies, 1968). For this reason, we recommend the presentation of raw scores in addition to percentile rankings and clinical interpretation.

Variability also exists in how certain neuropsychological tests are administered, and this will also effect the comparable the selected norms are. The two tests subject to the greatest variability in administration are the Logical Memory subtests from the original Wechsler Memory Scale and the Rey-Osterrieth Complex Figure. In the Logical Memory subtest (prose passage recall), scoring criteria do not exist to define what constitutes correct recall of each memory unit. Some neuropsychologists require verbatim recall, some will score the item as recalled if the gist of the element is remembered (e.g., kids for little children), and others employ a half credit scoring approach. Similar scoring ambiguities exist for the Complex Figure. Although the 36 scorable elements are described, the only criteria given are for whether the element is correctly placed, and whether or not the element is distorted or incomplete. Thus, considerable scoring variability exists among neuropsychologists for this test.

NEUROPSYCHOLOGICAL REPORTS

As with other laboratory procedures, the written report serves as the primary permanent record of the patient's performance. However, the neuropsychologist typically retains all of the scoring and test forms although this specific information is not routinely available to the referring physician. This situation is analogous to EEGs, in which a formal report is written describing the patient's record, but copies of individual EEG tracings are not included with the report.

A consensus does not exist within the neuropsychological community regarding the amount of test detail that should be included in a neuropsychological report. At one extreme is the position that only performance description should be included which, although based directly on neuropsychological test performance, does not mention tests by name. Thus, statements such as "verbal memory was severely impaired although more normal memory was present when a contextual cue for information was provided" or "severe visual-constructional deficits were observed" may serve as the primary source of information.

The rationale for not including specific test scores in a report is that not only are they meaningless for the vast majority of persons reading the report, but in addition, neuropsychological scores including IQ measures are subject to considerable misunderstanding and potential misuse. Thus, the scores are withheld from the formal report but are made available to appropriate individuals if they are requested.

At the other end of the spectrum is the presentation of all scores and percentiles. Some neuropsychologists will include scores with their description and interpretation, and others will present the scores separately as a summary information sheet. The rationale behind this approach is that since one strength of neuropsychological assessment is the systematic application of standardized tests, not to present the information is analogous to throwing away information. Specifically, it allows the referring individual to examine the performance and, perhaps, arrive at different conclusions. To not include information would be analogous to not providing CT or MRI films for evaluation and relying solely on the written interpretation of the scan. However, even when scores are presented in the report, the referring physician should be aware that the reliability of the corresponding percentile values may vary both as a function of the test and as a function of which particular set of norms is employed as discussed above.

INTEGRATION OF NEUROPSYCHOLOGICAL RESULTS WITH CLINICAL HISTORY AND NEUROLOGICAL FINDINGS

As with any consultation, posing a specific referral question and direct communication with the consultant will increase the likelihood of obtaining information that address the clinician's concern and provides valuable information for the care of the patient. The neuropsychological findings must then be interpreted within the context of the clinical history and neurological examination. For example, the neuropsychological finding of moderate anterograde memory deficits has distinctly different implications in an 18-year-old patient with recent head trauma compared with identical findings in a 76-year-old patient complaining of slowly increasing memory difficulty. In addition, the pattern of neurological and neuropsychological findings may be complimentary and thus enhance the diagnostic significance above either individual finding alone. For example, neuropsychological evidence of a mild language disorder in a patient with an equivocal right Babinski reflex increases the probability of a left hemisphere lesion.

CLINICAL JUDGEMENT AND EXPERIENCE

Experience is frequently used to justify an assertion that a patient put forth his or her best effort. However, clinical experience in neuropsychology is not sufficient to make reliable inference regarding potential malingering. A favorite question of defense attorneys is "If you were fooled, doctor, how would you know you were fooled?"

Heaton et al. (1978) reported the ability of neuropsychologists to detect faked neuropsychological performance. Level of general impairment (Halstead Impairment Index or FSIQ) was equivalent in moderate to severe head injury patients and in healthy subjects instructed to fake neuropsychological deficits. However, different patterns of deficits were produced. The malingerers tended to obtain high scores on the MMPI F scale and performed poorly on sensory and motor tests. However, neuropsychologists' ability to classify patients correctly as malingerers or head injury patients based solely upon neuropsychological test performances ranged from chance-level prediction to about 20% better than chance.

PROFESSIONAL QUALIFICATIONS AND TRAINING

Successful completion of a medical residency and board eligibility is frequently used to insure adequate training in medical specialties. However, clinical

neuropsychological training is more variable, and consequently, relying on board eligibility is even more important since it serves as an independent criterion with which to evaluate "education, training, and experience." The definition of a clinical neuropsychologist adopted by Division 40 (Clinical Neuropsychology) of the American Psychological Association describes the minimum training, and indicates that attainment of the American Board of Professional Psychology/American Board of Clinical Neuropsychology diploma is "the clearest evidence of competence as a Clinical Neuropsychologist." Thus, the neuropsychologist must have successfully completed both systematic didactic and experiential training in neuropsychology and neuroscience at a regionally accredited university. Current standards do not allow a psychologist to become a neuropsychologist by simple postdoctoral supervision, and the physician is entirely justified if a neuropsychologist does not hold an ABPP/ABCN diploma to ask about what formal training (other than supervised experience) has been obtained.

As with physician guidelines, board "eligibility" rather than board certification may be a useful measure of "education, training, and experience." Since the criteria described in the definition of a clinical neuropsychologist are essentially those requirements for eligibility for the ABPP/ABCN diploma, board eligibility should be the standard to insure adequate training in clinical neuropsychology. Although other boards of professional neuropsychology exist (i.e., American Board of Professional Neuropsychology, or ABPN (which is not the American Board of Psychiatry and Neurology), they are not held with the same esteem as ABPP/ABCN.

FUTURE DIRECTIONS

Clinical neuropsychology has been an area of rapid expansion and application in the 1980s. The rate of growth has slowed in the 1990s, although part of this slowing is undoubtedly due to concerns in the rapidly changing medical marketplace.

Neuropsychology has always embraced change and new approaches to assessment. Part of the changes that will continue to occur include improvement in sampling and normative information for current approaches to assessment. However, there will probably also be more fundamental changes in the approach to neuropsychological assessment that will occur that capitalizes on the rapid development of computers and virtual reality. Neuropsychology has been criticized for not testing enough real world behaviors. Consequently, driving capacity must be inferred indirectly based upon some informal combination of psychomotor speed, visual scanning ability, and general judgment. It soon may be possible to test driving in a virtual reality computer simulator in which specific conditions are presented and the patient's response measured directly. The conceptual extensions are limitless, and include shopping, cooking, or dressing simulations.

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