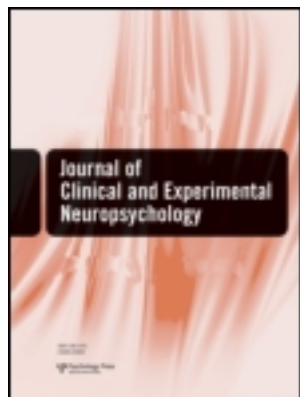


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Neuropsychological assessment: Principles, rationale, and challenges

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Neuropsychological assessment: Principles, rationale, and challenges

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Neuropsychological assessments are increasingly in demand for a wide range of patients. This paper offers a survey of the basic aspects of neuropsychological assessment that are of greatest importance for professionals (e.g., psychologists, psychiatrists, social workers, and lawyers) who are not trained in neuropsychological testing, but who refer clients for neuropsychological assessment. This survey could also serve neuropsychologists in their early stages of training, by addressing some of the major issues related to the assessment process. The range of goals that neuropsychological assessment may attain is first outlined. Next, a model is presented that explains the rationale enabling generalization from assessment to real-world functions that are the focus of interest and the target of prediction. Issues that need to be considered before deciding to conduct a neuropsychological evaluation are then introduced, and sources of information available to the assessor are described. A description is provided of what a neuropsychological assessment includes, with an emphasis on its cognitive aspects. Finally, mention is made of some of the difficulties and challenges that must be confronted in the course of a neuropsychological assessment.

Keywords: Neuropsychological; Assessment; Review.

The need for neuropsychological (NP) assessments has been increasing for various populations (e.g., developmental and acquired neurological disorders as well as psychiatric disorders) and for various purposes (e.g., planning rehabilitation and forensic issues). A wide range of professionals (e.g., psychologists, psychiatrists, social workers and lawyers), who are not trained in NP testing commonly refer clients for NP assessment. This paper offers a survey of the basic aspects of NP assessment that are of greatest importance for these referring professionals as well for neuropsychologists who are in their early stages of training in the field.

THE GOALS OF NEUROPSYCHOLOGICAL ASSESSMENT

There are many reasons that an individual might be referred for NP assessment. Over the years, these

reasons have changed due to developments in the field. In a recent survey of assessment practices of clinical neuropsychologists, Rabin, Barr, and Burton (2005) reported that “the most frequently endorsed assessment referral questions were determination of diagnosis, rehabilitation and/or treatment planning, and forensic determination” (p. 47). It is imperative to ascertain that expectations of the assessment are shared by the referring professional and the assessor. More detail is provided below.

Diagnosis

Until the 1950s, one of the main questions that NP assessment was called upon to answer was that of differential diagnosis. Classically, this was stated as the question of whether observed deficits were “organic” or “functional” (a code-word for psychological or emotional problems; see Lezak,

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Howieson, Loring, Hannay, & Fischer, 2004, p. 17). Later on, the question tended to be more focused on the area of brain damage that could be identified by a particular profile of cognitive deficits (for discussion see Reitan, 1989).

These questions were more common in the past, when diagnostic tools available to clinicians were more limited. Now a range of imaging techniques—both structural (computerized tomography, CT; magnetic resonance imagery, MRI) and functional (positron emission tomography, PET; functional MRI)—allow a more direct answer to the question of whether a patient has brain damage and, if so, what its location is. Such imaging techniques are especially efficient in providing visual evidence of vascular abnormalities, in which damage is focal and detectable. The situation is more complex in the case of more diffuse forms of damage, such as in the case of traumatic brain injury (TBI). This may involve damage to the white matter of the brain (diffuse axonal injury), which cannot be visualized with conventional CT or MRI techniques. One MRI imaging method that does have the unique ability to investigate the integrity of white matter tracks is diffusion tensor imaging (DTI; Wiesmann et al., 1999). This method became more widely used in the last decade as a result of the substantial research and development in this field (for review, see Tournier, Mori, & Leemans, 2011). The pattern of resting state functional MRI (fMRI) brain activity has been referred to as the default-mode network (DMN). This has become a fascinating research topic in the last decade. Abnormal patterns of DMN activity are associated with various mental disorders (e.g., schizophrenia, depression, anxiety, epilepsy, and autism; for review, see Broyd et al., 2009). Advancements in this field have the potential for significant contribution to diagnosis of neuropsychological disorders.

Despite the availability of imaging techniques, and even in cases in which damage can be visualized, there is still a role to be played by NP assessment, since it can properly evaluate and define the relationship between the direct effect of brain damage and of psychological factors that may result directly from the injury.

Furthermore, NP assessment can provide tools for differential diagnosis where clear cognitive decline is apparent, despite the absence of neurological deficits. Examples are cases of mild TBI tested days (Reitan & Wolfson, 2000), months (Geary, Kraus, Pliskin, & Little, 2010; Geary, Kraus, Rubin, Pliskin, & Little, 2011), or even six years (Konrad et al., 2011) post injury. However, see Belanger, Curtiss, Demery, Lebowitz, and Vanderploeg (2005) for factors (e.g., patient characteristics or

participants in litigation) mediating neuropsychological outcomes. Another example where NP assessment is used for differential diagnosis is for persons exhibiting mild cognitive impairment (MCI). The memory of these individuals is poorer than that of individuals matched for age and education, yet they do not reach the impairment level of patients diagnosed with dementia (Petersen et al., 1999). Several studies have reported the usefulness of NP assessment in the detection and characterization of subtypes of MCI (De Jager, Hogervorst, Combrinck, & Budge, 2003; Lehrner, Maly, Gleiss, Auff, & Dal-Bianco, 2008; Nelson & O'Connor, 2008; Teng, Tingus, Lu, & Cummings, 2009). Luis et al. (2011) showed the advantages in combining NP tests with biomarkers such as serum beta-amyloid. Finally, NP assessment is helpful in the differential diagnosis of a range of neurodegenerative disorders such as Alzheimer's dementia, frontotemporal dementia, and others (De Jager et al., 2003).

Forensic determination

Another type of NP assessment, generally encountered in the context of workers' compensation determinations and personal injury litigation cases involves determining whether the injured person is malingering or exaggerating the effects of the injury. According to the guidelines established by the American Psychiatric Association (APA, 1994), behavior may be described as malingering when it involves *intentional* exhibition of false or exaggerated physical or mental symptoms. Another requirement is that the reason for the false or exaggerated behaviors is the receipt of *external* reward, such as monetary benefit or exemption from military service or work (for operational definitions of differential diagnosis, see Slick, Sherman, & Iverson, 1999). It must be remembered that the situation is often complex, since real and exaggerated symptoms may coexist.

There are various strategies for the detection of malingering or noncooperation in the context of NP assessment. One approach involves analysis of a candidate's performance on standardized tests, to identify cases where performance is out of line with expectations, alongside indications of skewed results. For example, when performance on a recognition memory test is poorer than chance performance, it can be suspected that the examinee is making an intentional effort to perform poorly (for review, see Brandt, 1988). Another approach employs tests that were specifically designed to identify inflation of deficits. Such

tests assess performance patterns that are atypical of patients with bona fide neurological impairment (Larrabee, 2003). Opinions are mixed with regard to the question of whether the examinees should be warned that their cooperation is evaluated as well. Some suggest informing examinees that the tester is expected to report on the examinee's cooperation and that the tester will be employing diagnostic tools that might indicate suboptimal performance. In my experience such a declaration will lead anyone thinking of exaggerating the severity of his or her symptoms in most cases to reconsider. Other clinicians have opined that such warnings may complicate assessment and make it even more difficult to detect malingering (e.g., Greiffenstein, 2008).

Functional assessment

The most common current reason of referral for NP assessment is not to determine whether impairment exists, but rather, given the existence of the impairment, to assess its implications for the person's functioning. To fully appreciate the significance and consequences of an injury, it is not enough to measure a person's current level of function in comparison to some norm, but it is also necessary to estimate the person's premorbid capabilities and predict their future functioning. In other words, tests may enable us to rate an individual's performance relative to given population means, but such information is insufficient for proper assessment, as the premorbid abilities of some people were above average, and those of others were below average. For a thorough assessment, it is therefore necessary to have some indication of premorbid function. Such information has implications for both rehabilitation strategies and for forensic issues.

There is an extensive literature regarding methods of estimating premorbid function. Some approaches base assessment on performance of tasks that have been shown to be relatively immune to brain trauma, including subscales of the Wechsler Adult Intelligence Scale (Wechsler, 1997). A measure of relevance is the relationship between preserved subtests (e.g., Vocabulary) and impaired subtests (e.g., Block Design) in that instrument—that is, the “hold/don't hold” principle (see Lezak et al., 2004). Standard reading tests such as the Wechsler Test of Adult Reading (WTAR) or the National Adult Reading Test (NART) have also been found to index premorbid intellectual ability. An alternative approach is based on the assumption that the individual's best test performance is the optimal indication of his

or her premorbid function—that is, the “best performance” principle (see Hoofien, Vakil, & Gilboa, 2000, for a comparison of these two methods). Other approaches, such as the Barona Index, stress demographics such as years of education and vocational achievement as indicators of premorbid function (Barona, Reynolds, & Chastain, 1984). Baade and Schoenberg (2004) review methods for assessing premorbid abilities and stress the limitations of such methods, especially in cases on either extreme of the intellectual spectrum—the very gifted and the profoundly challenged. There have been several attempts to combine such methods using various weightings (for an extensive review, see Lezak et al., 2004; Strauss, Sherman, & Spreen, 2006).

For the same reasons applying to premorbid estimates of function, it is also necessary to attempt to predict future function. For example, it is important to make an effort to determine whether an individual with brain injury will be able to undertake academic study or to acquire a particular professional skill and whether they will be able to find work in the open market or be dependent on sheltered employment frameworks (see discussion of this issue below).

The reliability of the NP assessment and its ability to predict everyday function are the focus of many studies, some of which have been quite critical of the capacity of NP assessment to deliver what it promises (Sbordone, 1996; Silver, 2000; Wilson, 1993).

Design of rehabilitation programs

An additional goal of NP assessment is to assist in the development of a program of rehabilitation that will maximize each patient's functional potential. Wilson (1991b) demonstrated how the NP assessment can be used to plan a rehabilitation program and emphasized the important “role of theory in assessment for rehabilitation.” From the rehabilitation perspective, the goal of assessment is not just to locate and describe the various deficits caused by the patient's injury. No less important is the process of discovering the patient's preserved functions. A rehabilitation program not only attempts to ameliorate deficits or teach the patient how to cope with them; it also enables the patient to cultivate and optimize spared abilities for use as compensatory mechanisms that allow adequate optimal functioning despite his or her disabilities. Recommendations will generally address types of therapies to be carried out (e.g., psychotherapy and cognitive remediation), vocational

factors (e.g., sheltered workshop or integration into the open market), and educational prospects (the ability to study in academic institutions or the requirement for special educational frameworks). NP assessment is also used to predict and evaluate functional outcome (Bercaw, Hanks, Millis, & Gola, 2011).

Several researchers have stressed additional goals of NP assessment. For example, Sherer and colleagues (2002) list 11 goals of NP assessment, most of which are functions of the main goals noted above. They include providing feedback to patients themselves and to their families regarding their level of function, recommendations regarding returning to school or work, and evaluation of the effectiveness of pharmacological treatment or any other interventions.

FROM LABORATORY ASSESSMENT TO REALITY

As noted above, one of the goals of NP assessment is the prediction of the assessed individual's ability to function in everyday life, in work or school. The rationale that enables us to extrapolate from performance on a pencil-and-paper or a computerized

abstract task to the ability to cope with job responsibilities or educational activities is tenuous, and researchers have questioned the ecological validity of making predictions on individuals' performance in real-life situations on the basis of group results (Sbordone, 1996; Silver, 2000; Wilson, 1993). In an attempt to have tests that map directly onto real-life behavior, Wilson developed a series of such behavioral test batteries for the assessment of memory such as the Rivermead Behavioural Memory Test (RBMT; Wilson, Cockburn, & Baddeley, 1985), of neglect such as the Behavioural Inattention Test (Wilson, Cockburn, & Halligan, 1987), and of executive functions such as the Behavioural Assessment of the Dysexecutive Syndrome (Wilson, Alderman, Burgess, Emsile, & Evans, 1996). In these tests, "laboratory" items (e.g., paired associate learning cues) were replaced by items that better reflected real-life situations (e.g., remembering new names or routes). The ecological validity of these tests was shown in several research studies. For example, performance on the RBMT correlated significantly with therapists' observations (Wilson, Cockburn, Baddeley, & Hiorns, 1989). RBMT scores predicted long-term (5–10 years) independent living (i.e., paid employment and/or full-time education; Wilson, 1991a). RBMT scores also predicted

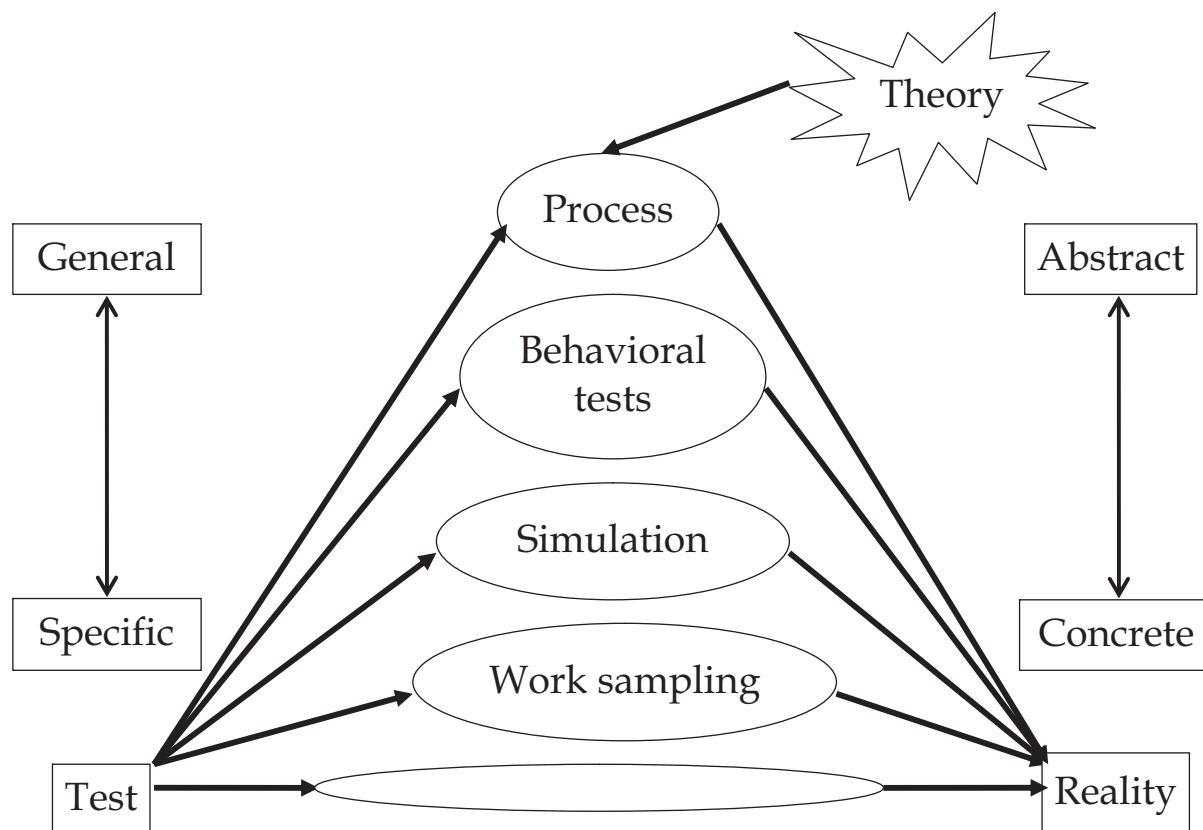


Figure 1. From test to reality—"hierarchical mediation model."

employment following severe head injury (Schwartz & McMillan, 1989).

The hierarchical mediation model (see Figure 1) introduced here, though it does not enable precise predictions to be made, attempts to provide a structured hierarchy of links between assessment and daily-life situations to predict a person's performance under various conditions. It should be viewed as a schematic framework presenting the clinician with options for how to go about making predictions regarding a person's "real-life" performance. The model presents the various assessment means available for the clinician to choose from, depending on the specificity of the question asked. This schematic model incorporates five levels of function, seen as representing points along a continuum rather than discrete states; the lower end of this scale represents direct tests of real-world performance, and the upper end represents cognitive abilities assessed by standard NP tests. The intermediate links represent various simulated approaches to predicting performance in real-life situations. The upshot of this model is that NP assessment is not necessarily the optimal solution for all situations and all questions regarding prediction of real-life functioning.

The basic level requires no mediation as it directly reflects the patient's ability. Thus, if we have a very specific question about a person's ability to carry out the functions required for a certain occupation, the optimal procedure is to have the candidate perform just those functions required by the situation of interest. The advantages of this solution are that it is of high predictive power, because it is direct and does not require an extrapolation of the observations. Its shortcomings are that it is difficult to generalize from this assessment to other situations, that it risks exposing the patient to an experience of clear failure, and that it can be expensive.

The middle ground is provided by representative work tasks and simulations; on the one hand they are similar to the real-world situation and yet can be standardized and controlled. They also enable a greater degree of generalization than the previous instrument, at the cost of having somewhat lower predictive power. Toward the upper level of this continuum are the "behavioral tests" developed by Wilson and colleagues (Wilson et al., 1996; Wilson et al., 1985; Wilson et al., 1987). As described above, these tests evaluate various cognitive domains by using items reflecting real-life situations (e.g., remembering new names). At the top of this continuum are conventional NP tests, where the "process" serves as the mediating link between assessment and reality. The rationale for

their use is that such "laboratory" tests can capture more precisely the cognitive processes that underlie the more complex real-life situations (Kaplan, 1988).

The challenge of effective assessment is to describe both impaired and preserved cognitive abilities, while at the same time characterizing the cognitive abilities required by relevant real-world situations. Matching the two sides of the equation enables the tester to properly predict the possibility of the assessed person's success or failure in various situations. As can be seen in this model, there is a tradeoff between assessment that provides very specific accurate answers to a particular question and a procedural assessment that provides long-term prediction regarding a broader range of questions and situations, but with less accuracy. One derivative prediction of the model is that even when a specific question is of interest, some consideration should be given to whether NP assessment is the optimal method for obtaining an answer. It is more than likely that experience in a particular situation of interest will provide a more reliable answer and require a more modest investment of resources.

Finally, whereas neurocognitive theory defines the cognitive processes we are trying to assess, as well as allowing us to analyze the cognitive processes required for function in a particular situation, several studies argue that the ecological validity of NP assessment may be limited, unless mediating factors of general mental state, health, and other environmental variables that affect a person's everyday function are taken into account (Chaytor, Temkin, Machamer, & Dikmen, 2007).

PREASSESSMENT

There are several factors that should be taken into account before deciding to conduct an NP assessment.

Reason for referral

Before conducting the assessment, it is important to coordinate expectations with the individual requesting assessment or the referring party, in order to clarify the questions that they expect to be answered. Based on those expectations, it should then be determined whether NP assessment is the most appropriate tool to answer the questions of interest. For some questions, it is preferable to refer the patient to other professionals, who possess the appropriate skills and training. For instance, for questions regarding independent daily living it may

be advisable to refer to an occupational therapist, and for questions having to do with language functions, a speech pathologist may be the appropriate assessor. Furthermore, if the question of interest is concrete and specific to a particular situation (e.g., can the person be reintegrated in his or her former workplace?), the best course of action might be to examine their competencies in the particular setting required rather than performing general assessment. This can save time and money (i.e., the basic level in the model, Figure 1).

Timing of the assessment

The process of recovery of impaired functions of various types after an acute injury tends to be described by a power function. Initially we often observe dramatic improvements, but as time passes, the rate of recovery tapers off until reaching asymptote. There is no single accepted view regarding the period of time that passes between injury and stabilization. Bond (1986) claimed that it takes 18 to 24 months after injury until spontaneous recovery is stabilized. However, rate of recovery is dependent on several factors such as age, location, and severity of the injury. Generally, the most notable improvements occur during the first year after injury; following that time, the degree of change is more gradual. Therefore, NP assessment should generally not be performed in the initial stages of recovery from severe TBI—for example, while the patient is still in a state of posttraumatic amnesia (PTA). There may be instances when testing should be done early—for example, to determine the patient's capacity to manage personal, legal, or financial affairs. Similarly, preliminary assessment may be conducted to help plan a course of intervention and treatment. For the purpose of long-term assessment, it is recommended not to conduct an assessment until at least six months have passed since the injury, in order to get a stable picture of the person's long-term functional prospects (see Lezak et al., 2004, p. 185).

Prior assessment (repetition or practice effects)

For various reasons, a patient may be referred for NP assessment even though an assessment has been conducted previously. For example, an insurance company that does not wish to rely on a prior privately initiated assessment may wish to conduct an assessment under their own auspices.

There are, however, important reasons, both clinical and psychometric, for avoiding reassessment if possible.

The clinical reason is that NP assessments can be difficult and frustrating experiences for the patient. Aside from the assessment being long and exhausting, it requires patients to confront their disabilities, a complex and painful experience that can often lead to negative reactions such as depression.

The psychometric consideration is that there is empirical evidence for the existence of a practice effect by which the prior assessment affects the results of following assessments. Such effects have been reported even for assessments conducted a year apart (Dikmen, Heaton, Grant, & Temkin, 1999). When there is no alternative to repeated assessment, it should be postponed as long as possible, and alternative tests or test versions should be employed whenever possible. Several studies (e.g., Wilson, Watson, Baddeley, Emslie, & Evans, 2000) have demonstrated effects of repetition even when alternative versions of the same test are employed. It appears that patients simply learn how to take the tests more successfully. Recently this issue has been examined using various approaches, involving the use of repeated assessments to determine the degree to which examinees derive benefit from prior exposure to the test type, as well as consistency in performance.

Greiffenstein (2008) has made two very important points regarding this issue. First, results of retesting could be very informative. For example, benefit from retesting might reflect a person's real effort or vice versa. Second, the available empirical research on practice effect could direct the clinician as to how to interpret the findings because the practice effect is dependent on various factors such as nature of the test, severity of injury, and so on. Dikmen et al. (1999) have also demonstrated that the magnitude of the practice effect using the Halstead-Reitan NP Test battery is dependent on several factors such as the type of measure, age, and test-retest interval.

SOURCES OF INFORMATION FOR ASSESSMENT

Luria described NP assessment as “neuropsychological investigation” (Luria, 1966). In any investigation, one should begin by *data collection* and assessment of the correlations and contradictions between various sources of information. Next, *hypotheses* regarding the patient's condition should be formulated, and those hypotheses *evaluated* in

light of collected data that verify or confute them. When the data do not support the initial hypotheses, alternative hypotheses should be formulated, with the hope that they will do a better job of explaining the test findings. What then are the sources of information available to us for the purpose of the NP investigation?

Self-report and family reports

Information is required from the patient and family members (or significant others) regarding the patient's history, lifestyle, and functional capacities, both prior to and since the injury. Information regarding the period prior to injury is vital for estimation of premorbid level of function, which is required for accurately assessing the losses caused by the injury. This information also allows us to understand the patient's plans and aspirations before injury and to examine whether those ambitions are appropriate given his or her new postinjury realities. Information gathered from the patients and family members about postinjury condition is also vital. Knowledge about the patients' failure/success when attempting to return to work or school following the injury could tell us about the patient's coping and adjustment skills and attitude towards rehabilitation. Leisure activity could tell us about the patient's emotional status, as well as about the social support he or she is getting. These kinds of information could be very useful in predicting the potential for future rehabilitation.

Level of self-awareness can be judged by comparing the patients' self-estimation of cognitive function with objective measures provided by testing. Impaired self-awareness of the person's deficits may reflect a metacognitive failure characteristic of individuals who have sustained frontal lobe and/or right hemisphere injury (Allen & Ruff, 1990; Prigatano & Altman, 1990). Evans, Sherer, Nick, Nakase-Richardson, and Yablon (2005) have found that impaired self-awareness was associated with subjective well-being in patients with TBI. Discrepancies between reports by a patient and family members, particularly regarding changes in mood and behavior, are very informative. This information reflects the patient's self-awareness of the effects of the injury not only on cognition but also on mood and behavior. It is to be noted that discrepancies between patient self-report and family reports are of great diagnostic value and may serve as an important basis for recommendations

regarding the necessity of individual or family therapeutic interventions.

Records and documentation

It is quite common for patients and their families to exaggerate (intentionally or unintentionally) the patient's premorbid abilities and to portray his or her capacities in a far more flattering light than past reality justifies. Greiffenstein, Baker, and Johnson-Greene (2002) document the tendencies of TBI patients to exaggerate their premorbid academic achievements. One method of controlling for this tendency is examination of records and documentation of the patients' past achievements. Likewise, it is important for the assessor to have before them the patient's case documentation and any past assessments performed by medical and paramedical professionals. Such information allows the assessor a broader perspective on the consequences of the injury and can enable a more balanced and comprehensive assessment.

Observation

NP assessment generally takes several hours and is performed over the course of several sessions. Careful observation of the patient during the course of the assessment can complement test results, emotional state, cognitive abilities, and behavioral changes. It allows us to learn about his or her emotions and ability to deal with frustration. It reveals whether the patient is motivated to succeed or, alternatively, simply radiates helplessness. Observation may also tell us about the patient's cognitive difficulties—for example, how distractible they are, how often they need a break in the performance of a task, their level of awareness, and their ability to comprehend and remember instructions. Behavioral changes caused by injury may also be assessed effectively by careful observation. During the course of the assessment, we can learn whether there are indications of disinhibition, which may be expressed through a disregard for social boundaries and situationally inappropriate behaviors. Additionally, apathetic behaviors and lack of initiative may be observed. Such problems might be expressed by the patient's extreme passivity and complete lack of initiative—for example, not asking questions regarding the makeup of the assessment or the time frame of the testing, or inaction pending explicit instructions for every action.

Neuropsychological tests

There are a large number of neuropsychological tests that have been designed to assess a wide range of cognitive functions. These have been comprehensively surveyed, by Lezak et al. (2004) and Strauss et al. (2006).

WHAT DOES A NEUROPSYCHOLOGICAL ASSESSMENT INCLUDE?

Stuss and Levine (2002) identified two major historical approaches to NP assessment. They refer to the first as the “psychometric” or “quantitative” approach and the second as the “clinical” or “qualitative” approach. In the first approach, assessment is based on a fixed battery of standardized tests such as the Halstead–Reitan Neuropsychological Test battery (Reitan & Wolfson, 1993) or the Luria–Nebraska Neuropsychological Battery (Golden, Hammeke, & Purisch, 1976). Diagnosis is based on norms, and classification of patients is derived from the profile of the results. In the second approach, the emphasis is on individual differences rather than norms. The tests are very flexible and are adjusted to the particular patients. The person most representative of this approach is A. R. Luria (Luria, 1966).

Each approach has its advantages and disadvantages (for discussion of this issue, see Stuss & Levine, 2002). The Boston Process Approach (Kaplan, 1988) could be viewed as a synthesis of the advantages of both. On the one hand, the tests used are standardized, but at the same time the assessment is not based just on the quantitative aspects of performance but also on its qualitative aspects. The focus is on the analysis of the process that led the patient to the answer (whether it was right or wrong) and not looking just at the final score. In the hierarchical mediation model presented above, the process approach reflects the top end of the continuum of links between assessment and daily-life situations.

In the past, it was the accepted practice to conduct NP assessment using a fixed test battery that left little freedom of choice to the assessor. Among the most well known of these are the Halstead–Reitan battery (Reitan & Wolfson, 1993), the Christensen–Luria battery (Christiansen, 1979), or another version of batteries based on the tests developed by A. R. Luria, especially the Luria–Nebraska Neuropsychological Battery (Golden et al., 1976). Today most neuropsychologists make use of a flexible test battery (see Rabin et al., 2005, for the tests frequently used). This

enables updating of the tests and the construction of a combination of tests suited to the examination of a particular question, and customization for persons with special needs (such as those with motor problems). A proposal for such a battery can be found in Lezak et al. (2004).

NP assessment is often considered to be first and foremost a cognitive assessment, possibly because cognitive abilities can be measured and quantified reliably. Additionally, there is an extensive literature that describes the cognitive consequences of various types of brain injury. Having said that, it should be remembered that brain injury might also lead to changes in emotional state and in behavior, and those changes must be assessed as well. A thorough description of the effects of the brain injury on the person's function can only be achieved by an integrated evaluation of all these areas.

Psychoaffective evaluation

Studies of the long-term effects of brain trauma report a significant rise in the frequency of a range of psychiatric disorders among brain-injured people. Koponen et al. (2002) did a 30-year follow-up of head injuries and found that in 26.7% of the cases the injured person subsequently suffered from depression. Deb, Lyons, Koutzoukis, Ali, and McCarthy (1999) investigated status one year after brain injury and found that the frequency of depressive disorders among the brain injured was 13.9% as opposed to 2.1% in the general population. These findings exemplify the difficulty sometimes encountered in making a differential diagnosis, since it is not unusual for brain injury symptoms to be accompanied by psychoaffective disorders. At the same time, it should be remembered that some symptoms of brain injury, such as lack of initiative or disinhibition, can mistakenly be attributed to psychiatric causes, when in fact they reflect frontal lobe injuries.

Psychosocial assessment

Several scales have been developed in order to evaluate the psychosocial effects of TBI (for review, see Lezak et al., 2004, pp. 727–734). Brain injury, especially of the prefrontal lobes, can lead to a deficit in behavioral control. Such deficits may be expressed in various ways. For example, Tekin and Cummings (2002) distinguished between the effects of lesions of various prefrontal areas: Damage to the dorso-lateral prefrontal cortex brings about disorders of executive function (see below), while orbitofrontal

damage is expressed in disinhibitory behavior, such as asking the tester inappropriate personal questions. Damage to the anterior cingulate gyrus will lead to apathy, passivity, and lack of initiative. Such a patient will act only in response to a direct request by the tester. He will not, of his own initiative, ask questions about the assessment (e.g., the goals of a particular test, how long the assessment will take). Such behavioral assessment is not based on structured testing but relies on observation and reports by patients and their family members.

Cognitive assessment

Cognition is not a unitary entity, and distinctions must be made between various types of thinking. Wilson (1991b) emphasizes the critical role of theory in the process of assessment. A theoretical model should guide the clinician as to the components of cognition to be evaluated. One needs to adopt a theoretical model of attention, memory executive functions, and so on in order to decide which of these cognitive domains may be compromised and as a consequence what kind of tests are the most appropriate to evaluate their components. In addition, a theoretical perspective is required in order to enable the interpretation of the findings in terms of what profile of performance reflects a dysfunction of a particular brain area (see Figure 1).

Based on their survey, Rabin et al. (2005) conclude that “overall, there was great consensus regarding the types of abilities evaluated. For example, attention, construction, executive functions, intelligence, language, motor skills, verbal and nonverbal memory, and visuospatial skills were endorsed as ‘frequently’ assessed” (pp. 47–48).

Each of these areas of cognition comprises subprocesses that have been delineated by years of research in psychology and ancillary disciplines. Many of these subprocesses have been shown to be mediated by specific brain regions. As a result, within the same cognitive domain some aspects may be impaired while others are preserved. Therefore, the general statement that “the patient has memory problems” is diagnostically insufficient, unless it is accompanied by detailed reports regarding the various aspects of memory that are impaired.

Researchers often disagree about the internal components and interactions of the various cognitive categories, depending on their theoretical framework. Such differences may lead to the selection of different neuropsychological tests to assess a given function or subprocess.

Attention

Attentional processes are required for the execution of all everyday directed activities, and, as a result, they are a factor in most tasks utilized to assess cognitive functions. At the same time, all tests of attention require the involvement of other cognitive processes as well. Therefore, attentional deficits affect performance on most tests that make up the assessment. In order to control for the obscuring effects of other cognitive capacities on the assessment of attentional function, attention is generally assessed using very simple tasks in which speed of execution is stressed. There are several theoretical frameworks according to which it is possible to define the attentional components that should be assessed (e.g., Mirsky, Anthony, Duncan, Ahearn, & Kellam, 1991; Posner & Petersen, 1990). Attentional measures examined include “focal attention,” tested by requiring the examinee to ignore interfering stimuli, “divided attention,” in which the examinee must simultaneously relate to two concurrently appearing stimuli, and “vigilance,” which tests how long the examinee can stay focused on a task. Mateer and Mapou (1996) have attempted an integration of the various models of attention in order to characterize measures operationally in the NP assessment.

Perceptual processing

Based on earlier research on animals, Farah (2003) distinguishes between two types of deficit in visual processing. One involves problems in identifying visual objects and is caused by damage to the ventral “what” stream of cortical processing, while the other involves deficits in spatial orientation and is caused by damage to the dorsal “where” stream of cortical processing.

The group of deficits in visual identification known as *agnosia* reflects malfunctions in the various stages of visual object processing in the ventral stream. When complicating factors such as ocular or linguistic deficits have been ruled out, difficulties in the more basic stages of visual object processing are called *apperceptive agnosia*, while deficits arising from difficulties in the more advanced stages are called *associative agnosia*.

McCarthy and Warrington (1990) distinguish between two forms of visual spatial cognition arising from different levels of processing in the dorsal stream. The first type is a deficit in the ability to locate an object in space, and the

second type requires a more complex level of processing of several stimuli and analysis of the relationships between them.

Learning and memory

As is the case with the other forms of cognition, memory can be classified on the basis of several dimensions: time frame, perceptual modality, process, and retrieval conditions (see Figure 2). The importance of the time frame of memory is that it enables the characterization of mnemonic deficits in amnesia. According to Parkin (1997), in amnesia, working memory and memory of events in the distant past will be preserved, while transfer of new information into long term memory will be impaired.

Retrieval conditions are important since they may aid characterization of memory deficits incurred as a result of frontal lobe damage. Such damage often causes selective deficits in free recall accompanied by intact recognition memory (Janowsky, Shimamura, Kritchevsky, & Squire, 1989). Tests that simultaneously provide several memory measures, such as the Rey Auditory Verbal

Learning Test, are advantageous in enabling mapping of a range of memory abilities based on the same test (Vakil & Blachstein, 1997).

Abstract thinking and executive functions

One of the most characteristic cognitive deficits following frontal lobe damage (especially in dorsolateral regions) is decline in abstract thinking ability (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). Bruner (1957) defined abstraction as ability to go beyond given information, and, indeed, patients with frontal lobe injury characteristically exhibit rigid, concrete patterns of thinking. They have difficulty in understanding metaphors and parables that require comprehension of meanings below the surface of what is said. Such abstract thought is what enables us to execute thought processes such as generalization and categorization.

A related consequence of frontal lobe damage is impairment in executive functions (Shallice & Burgess, 1991). Welsh, Pennington, Ozonoff, Rouse and McCabe (1990) define executive function as the “ability to maintain an appropriate problem solving

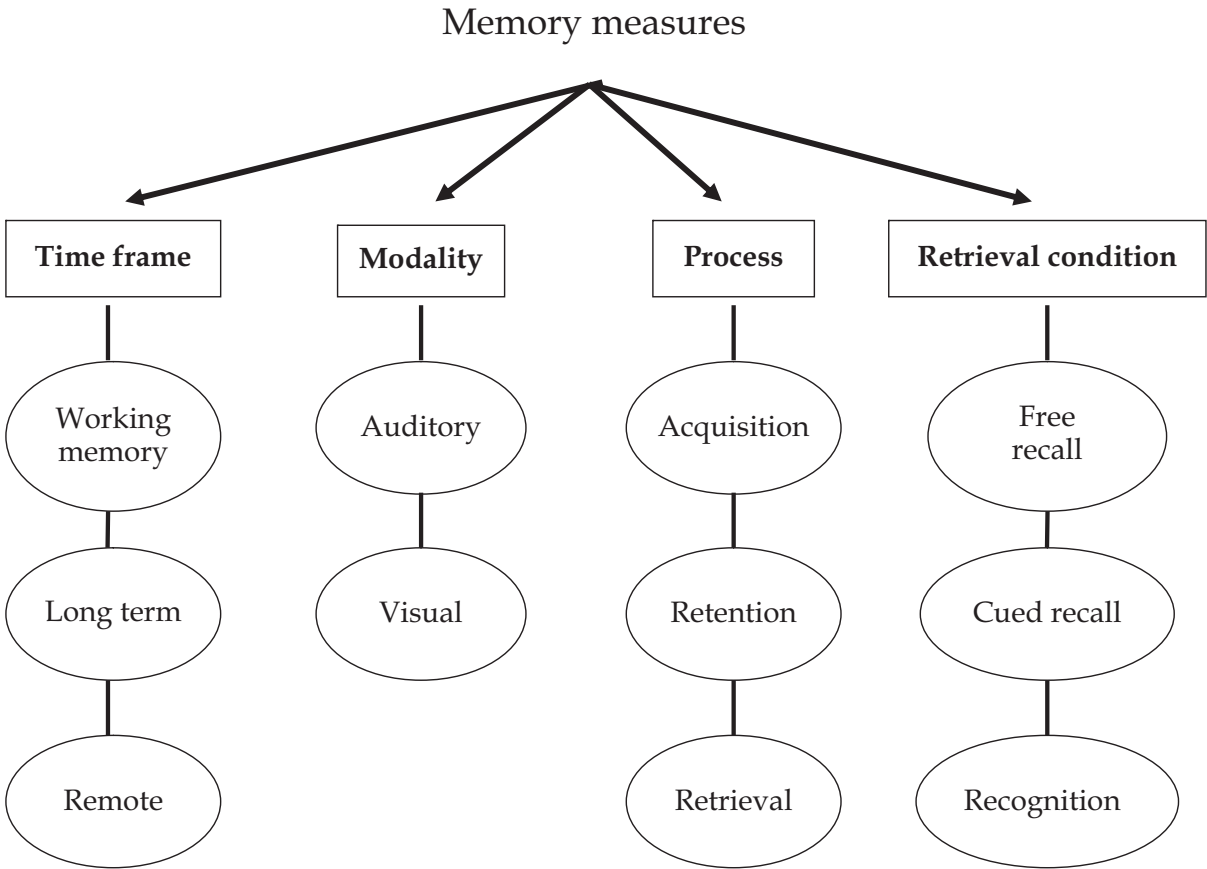


Figure 2. Variety of memory measures.

set for attainment of a future goal” (p. 1699). Such functions enable us to deal with new, unexpected situations for which we have no prepared solutions (Shallice, 1990). These are functions that are characterized by goal-driven behavior, including planning, priming, inhibition, and monitoring (Tranel, Anderson, & Benton, 1994). Deficits in these functions (i.e., dysexecutive syndrome) can lead to difficulties in decision making and problem solving, and to inappropriate social behavior.

DIFFICULTIES AND CHALLENGES IN NP ASSESSMENT

Interaction between cognitive and psychoaffective problems

In the above section, we have described psychoaffective and cognitive consequences of brain damage as two separate phenomena. While such problems may occur independently, interactions between them often complicate and worsen the patient’s overall situation. Poor psychoaffective status affects cognitive functioning, as shown by many studies that have demonstrated decline in various cognitive measures in patients with bipolar disorder (for review, see Quraishi & Frangou, 2002). On the other hand, cognitive decline may adversely affect one’s emotional state. Many patients experience cognitive decline as a form of loss and respond accordingly, *inter alia* exhibiting depression, loss of self-esteem, and, on occasions, helplessness and functional dependence on others. Insight into the interactions between the two kinds of deficits may accentuate the difficulty in making differential diagnoses and understandably may impact on the choice of treatment.

Interaction between types of cognitive function

It should be remembered that there are no “pure” tests of a single type of cognitive process. Every test comprises a number of cognitive processes. The challenge facing the examiner is to isolate the various cognitive processes that are required to perform the tasks of the test. The more we can isolate the cognitive process being assessed, the better the prognostic value of the test. This is one of the fundamental claims of the Boston process approach (Kaplan, 1988). For example, poor performance of tasks requiring memory for visual forms, such as the Rey Complex Figure test, may result from deficits in visuospatial perception or from deficits

in visual memory. Isolation of the impaired ability can be achieved by examining the copying portion of the task; a poor copy in the absence of motor impairments might indicate that the patient has perceptual problems, while a good copy but poor drawing from memory after a delay may indicate that the deficit is mnemonic rather than perceptual. This provides an example of a primary process (perception) affecting performance on a test of a secondary process (memory). Sometimes the influence is in the opposite direction, and it is important to exercise caution and to attempt to partial out such impact. For example, a person with good abstraction abilities may compensate for memory problems by using top-down strategic processes such as categorization or formation of associations between test items. One approach that can assist in estimating the degree of compensation is comparison of performance on a task in which strategies may be employed (such as story recall) with tasks in which such strategizing is less effective (such as memory for lists of nonwords).

Understanding the relationship between process and performance

In most standardized tests, assessment is based on comparing actual performance with performance expected on the basis of appropriate norms. Such norms allow the consideration of the examinee’s scores in light of population averages. The problem is that different individuals may obtain the same level of performance as a result of a range of abilities or deficits, which are not properly characterized by the overall test results. Researchers who became aware of this problem developed an approach that emphasizes analysis of the process of performance, not only of the final scores. One of the best known of such methods is the Boston process approach (Kaplan, 1988). Whether performance is impaired or preserved, it is possible to track the process of performance and thereby to understand the strategy employed by the examinee. For example, careful recording of the process of performance of the Rey Complex Figure Test of visual memory, mentioned above, enables analysis of the strategy employed by the examinee. He or she may execute the task using a “local” strategy—going from details to the overall picture—or by using a “global” strategy—starting with the whole and then proceeding to the details. Such information, which characterizes different cognitive strategies (the former reflecting left hemisphere processes and the latter right hemisphere processes), may not be reflected by the final performance score (Kaplan, 1988). In light of this fact, it may be argued that one reason for preferring

a particular NP test over another is the characteristic of complexity that enables analysis of qualitative characteristics in addition to quantitative measures (e.g., the Rey Auditory Verbal Learning Test; Vakil, 2006; Vakil & Blachstein, 1997; Vakil, Greenstein, & Blachstein, 2010).

Integration of advance computer-based technologies in NP assessment

In his book “Neuroinformatics for Neuropsychology” Jagaroo (2009) points out the fact that NP assessment remained unsophisticated compared to the significant advancements made in the last decades in related areas of neurosciences, such as neuroimaging and cognitive neuroscience. He claims that this lag could be reconciled if assessment took a more computational dimension. Consistent with this assertion, most of the testing methods described so far in this review are based primarily on old paper-and-pencil tools. Nevertheless, the rapid electronic technological changes taking place in the last few decades have already started to impact on NP assessment. Bilder (2011) views this change as the entrance to the third phase (Neuropsychology 3.0) of the development of neuropsychology. There is no doubt that the field of NP assessment is going to move progressively towards integration of advanced technology and computer-based tools (for review, see Bilder, 2011; Jagaroo, 2009).

As of today, there are at least three broad domains in which the integration of advanced technology is evident: computerized assessment, Internet, and virtual reality.

Computerized assessment

Computers have been utilized in the context of NP assessment in three different ways: first, to assist scoring of existing paper-and-pencil tests; second, to administer the tests; and, third, to offer interpretation to the performance (for review of computerized technology available for various tests, see Luciana, 2003).

Assisted scoring. Based on normative data, a computer can easily transform raw scores to standard scores (Luciana, 2003). There are clear advantages in using a computer program to calculate the standard scores. It eliminates the potential errors that could be made in the transformation. It saves time and effort, and the scores (speed and accuracy) could be generated immediately and presented in table or figure form, enabling the assessor to see patterns and profiles of performance more clearly.

Furthermore, such scores could be added automatically into a data bank.

Administration. There are various versions of computer-based NP assessments. The basic type is that in which a transformation of a specific standard paper-and-pencil test to a computerized version enables standardized administration and recording of results—for example, the Wisconsin Card Sorting Test. The other option is building an NP test battery that includes several tests, which in most cases are an adaptation of a paper-and-pencil test to a computerized version. Some of these batteries are “theory driven,” and others are “purpose (or problem) driven” (Schlegel & Gilliland, 2007). The theoretically driven batteries were constructed to cover a range of cognitive domains (e.g., attention, memory, executive functions, etc.) typically evaluated in standard NP batteries. The Cambridge Neuropsychological Test Automated Battery (CANTAB; Robbins et al., 1998) is a good example of such a battery that is used for NP assessment. This battery tests visual memory, visual attention, working memory, and planning. The purpose-driven batteries are computerized tests aimed primarily to be used for a specific goal such as synchronizing stimuli with fMRI, or testing symptom validity (see Schatz & Browndyke, 2002).

There are several advantages in this approach. The test administration is more reliable and enables randomized presentations, the rate of stimuli presentation is controlled, and the accuracy of response recording, including measuring reaction time, is measured in milliseconds. Finally, it is usually easier to develop several versions of the test to allow multiple testing (Cernich, Brennana, Barker, & Bleiberg, 2007; Schatz & Browndyke, 2002). At the same time, such computerized batteries have serious drawbacks. First of all, it could affect performance of individuals who are more as compared to less familiar with computers, or even have an aversion to computers (Feldstein et al., 1999). Second, it is less flexible if changes are required—for example, a clarification or a break. Third, the examinee’s responses are registered via key press or touch screen, so that much of the information gained by observation of spontaneous behavior is lost. Thus, by their very nature, they limit the opportunity for interaction between examiner and examinee, which makes it difficult to conduct a qualitative analysis of performance, given the emphasis on the final score as opposed to the process by which it is attained (i.e., process approach). As argued above, making an assessment solely on the basis of final scores can lead to errors, because vital information arising from

analysis of the process of performance is not taken into account (Luciana, 2003; Schatz & Brown dyke, 2002). Of course, computerized systems can provide valuable data about performance process—for example, error types, response preparation time, and so on (for review of advantages and disadvantages, see Schlegel & Gilliland, 2007). Therefore, the challenge is to create more flexible computerized assessments that will enable involvement and monitoring by the examiner in a way that yields information about the processes employed in performance.

Interpretation. Based on the standard scores calculated by the computer for the various raw scores, an interpretation of the results is offered, indicating in which areas tested performance is above or below or in the normal range. It could identify a profile of performance that is typical of a particular disorder. See Luciana's (2003) summary for computer programs for scoring, administration, and interpretation available for pediatric neuropsychological assessment. Adams and Heaton (1985) point to the limitations of computer-based interpretations (but see Russell, 1995).

Schulenberg and Yutrzenka (2004) raised several potential ethical problems that might emerge in the use of computerized assessment. The potential of ethical problems is particularly salient in the misuse of interpretation software by a person not sufficiently competent, who lacks neuropsychological knowledge and training, but is nevertheless tempted to use such software. The increased trend in using computer-based tests led the American Psychological Association (APA) in 1986 to published the *Guidelines for Computer-Based Tests and Interpretations* (see also Schatz & Brown dyke, 2002; Silverstein et al., 2007).

Internet

According to Bilder (2011) one of the changes expected in the transition to the third phase (Neuropsychology 3.0) of the development of neuropsychology is the increase use of Web assessment methods. It is also referred to as "remote neuropsychological assessment (RNA)." This method would enable collection of neuropsychological data from very large samples that would be stored and used for clinical and research purposes. Erlanger et al. (2002) developed the Cognitive Stability Index (CSI), used as a neurocognitive tool via the Internet as a screening and monitoring cognitive function. The same group, Erlanger et al. (2003), also developed an online tool, the Concussion Resolution Index (CRI), which measures simple and complex reaction time and speed of processing. This tool

is used to monitor sport-related cognitive changes. Silverstein et al. (2007) have developed and validated the WebNeuro, which is a Web-based neurocognitive assessment battery. Beside the obvious advantages of Web-based tools, the disadvantages raised above regarding computer-based tests are even more pronounced here. That is, it is very difficult to monitor the behavior of an examinee taking the tests at a remote location.

Virtual reality (VR)

The fact that three-dimensional VR vividly simulates the natural environment increases its ecological validity. At the same time, it remains a controlled setting in which various variables can be recorded, controlled, and manipulated (e.g., in terms of difficulty level, feedback; Rizzo, Schultheis, Kerns, & Mateer, 2004). Schultheis, Himmelstein, and Rizzo (2002) reviewed several attempts to implement VR in the assessment of a particular cognitive domain (i.e., executive functions, attention, visuospatial, and memory processes).

In the perspective of the hierarchal model presented above, VR simultaneously provides the benefits of both real-world and controlled laboratory conditions. Furthermore, VR enables the person to interact with the virtual environment, allowing a more dynamic evaluation of complex and multimodal stimuli, which better simulate the real world (Schultheis et al., 2002). The characteristics of VR potentially allow natural transition from evaluation to intervention. Within the same setting that detected the person's difficulties, cues and feedback could be gradually presented as a systematic remediation program. Although the cost of the various forms of VR technology (e.g., head-mounted displays, 3D rooms) is decreasing continuously, it remains expensive enough to prevent it from being widely used at present.

CONCLUSIONS

The demand for NP assessment in many different populations is growing. This review paper has surveyed several aspects of assessment. The survey demonstrates the complexity of NP assessment and the degree of knowledge and skill required to obtain optimally reliable and valid information from such testing. Indeed, NP assessment is a "neuropsychological investigation," as Luria so insightfully put it over four decades ago (Luria, 1966). It is important that the information presented above be available not only to clinicians conducting NP assessment

but also to those who require such assessment—referring clinicians and the examinees themselves. The success of NP assessment vitally depends on the ability of the end users of its results to clearly define their questions of interest and to provide all available relevant information that can increase the validity of assessment.

Rapid advances in brain research and cognitive sciences necessitate constant upgrading of assessment instruments and indicate the need for ongoing updating of knowledge so that interpretation of results will be based on firm theoretical and empirical grounds. There are still many problems and challenges to be overcome so that more widespread, informed, and effective use may be made of NP assessment.

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