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The WJ-R and Batería-R in Neuropsychological Assessment

Research Report Number 3

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THE WJ-R AND BATERÍA-R IN NEUROPSYCHOLOGICAL ASSESSMENT*:

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This report provides an overview of traditional and contemporary neuropsychological practice. A cognitive neuropsychology model, grounded in Gf-Gc *theory and information processing theory, is offered as a unifying portrayal of human cognitive functions and their assessment. The* Dean-Woodcock Neuropsychological Assessment System *(D-WNAS) is presented as a comprehensive system designed to assess most aspects required for a variety of comprehensive neuropsychological evaluations. The core of this system includes the English and Spanish language versions of the* Woodcock-Johnson® Psycho-Educational Battery–Revised *(WJ-R®) and the* Dean-Woodcock Sensory Motor Battery *(D-WSMB). The use of the Focused Norms Calculator to obtain standard scores adjusted for age, education, and gender is described as a special interpretive feature of the System. The final section of this report presents results of a number of research and case studies from a sample of 1,315 clinical subjects from 5 to 81 years of age.*

Section I: Introduction

The relationship between human behavior and brain function has intrigued scholars for centuries. Although the antecedents are clear, our knowledge of the relationship between the behavior and the integrity of the central nervous system owes more to the research vigor of the past 30 years than any other time in history. Of continuing interest has been evidence of the correspondence between areas of the brain and cognitive, sensory-motor, and affective functioning. With this knowledge as a foundation, the development and validation of standardized methods of observing behavior, allowing for inferences concerning individual's cortical functioning, have come.

This body of knowledge has become known as neuropsychology and seeks to relate behavior to brain functioning. Within the general field of neuropsychology, neuropsychological assessment has evolved as a method of defining the functional integrity of the brain by observing behavior under standardized conditions. This section of the report provides the theoretical

*Appreciation is expressed to the following individuals who have supplied much of the clinical data reported here. Without their generous contributions of data and time, this report would not have been possible. Scott Hill (Salt Lake City, Utah), examiners for Raymond Dean (Ball State University, Muncie, Indiana), Graham Neuhaus (Texas), Joseph D. Eubanks and Mary Waggoner (Texas Neurosciences Institute, San Antonio, Texas), Kimberlee J. Sass (Yale University School of Medicine), John Harvey and Robert Cole (Allied Services Rehabilitation Hospital, Scranton, Pennsylvania), Daniel C. Miller (Texas Woman's University), and James Evans and Roger Carlsen (University of Dayton).

framework for the *Dean-Woodcock Neuropsychological Assessment System* (D-WNAS) (Dean & Woodcock, in preparation) as a method in which both neurological and psychological data are integrated into a comprehensive view of an individual's level of functioning. Indeed numerous authors have argued in favor of such a neuropsychological perspective in our understanding and diagnosis of neurological, psychiatric, and educational disorders.

Historical Overview

Ultimately, all voluntary human behavior may be traced to the functioning of the brain. The studies of the nineteenth century which based conclusions about normal brain functioning on case studies of patients with diseased brains can be criticized. However, these early investigations led to our present understanding of the relationship between behavioral defects and cerebral impairment. The idea of one-to-one correspondence between behavior and localized micro-structures of the brain may seem naive by today's standards. It is now recognized that the location, magnitude, and chronicity of a brain lesion interact with developmental history and individual differences in such a way to make highly specific localization of a function tenuous. Thus, although rather clear knowledge of the location of a lesion may be available for a patient, rarely is it possible for the neurosurgeon or neurologist to make specific predictions about the patient's behavioral functioning.

As in most areas of measurement, neuropsychological assessment grew out of a need in an applied area. In the case of neuropsychology, the most salient influence has been the desire on the part of the medical community to more fully describe the behavioral effects of brain damage. Neuropsychological assessment has often been considered an adjunct to the neurological examination. Basically a noninvasive technique, neuropsychological assessment was often seen as a viable alternative to physical diagnostic procedures which often held a mortality probability in themselves (e.g., angiogram).

The administration of experimental and standardized psychological measures to patients with documented structural brain lesions gave rise to a data base which allowed investigation of the sensitivity of these measures to brain damage. In the post-World War II years, these data were expanded with the relatively large number of patients with documented brain lesions resulting from head wounds. Such events, when combined with the growing empirical emphasis beginning in the decade just prior to World War II, nurtured a quantitative approach which continues to characterize neuropsychological assessment in North America. Moreover, theoretical notions concerning brain function mattered less than the utility of assessment procedures in predicting and localizing cortical damage (Reitan, 1955).

Neuropsychological assessment represents an interaction between behavioral neurology, experimental psychology, and advances in psychometric theory (Dean, 1986). This is clear in neuropsychological assessment procedures presently in use. With few exceptions, current batteries in North America are either versions of pre-existing clinical procedures or clinical adaptation of laboratory procedures. Early on, the specific procedures included in test batteries were based more on their ability to predict the presence of brain damage than any underlying theoretical notion of the functioning of the brain (Reitan, 1955). Indeed, testing procedures were included or excluded based on their ability to localize and/or predict the presence of neuropathology in patients with known brain lesions (Reitan, 1955).

Theoretical Approaches

The major focus of the *quantitative* (structural) *approach* of North America has been on the development of test batteries which allow the identification of aberrant neurological conditions from a structural point of view using standardized methods and comparisons with normative samples. This point of view is exemplified by Reitan (1955, 1966) and reflected in the construction of the *Halstead-Reitan Neuropsychological Test Battery* (1993). Because the methods of the quantitative orientation have been adopted on the basis of predictive efficiency, this approach which provides continuous predictive validation, is most frequently faulted as being atheoretical and lacking data necessary in understanding and documenting the loss of individual functions (Luria & Majovski, 1977).

In contrast, Luria (1966) proposed a more *qualitative approach* which focuses on “pathognomonic signs” useful in understanding a patient’s functioning. Luria’s theoretical view of cortical functioning rests on the development of specific assessment techniques which would lead to rehabilitation strategies. Similar to many of Luria’s (1966) arguments, a number of neuropsychologists have stressed methods that view neuropsychological assessment as a dynamic, interactive process. From this point of view, the importance of diagnosis is subserved by the concern for providing a comprehensive view of a patient’s total functioning.

As opposed to other theorists who have argued that functions are discretely localized in specific areas of the brain, Luria (1970) and proponents of the qualitative school maintain that higher forms of human cognitive activity (e.g., memory) are based on the participation of all levels of cerebral activity and are more heuristically organized into functional systems of the brain. The crux of Luria’s observation-based approach had been a syndrome analysis or a “qualification of the symptom” in which behaviors were described and hypotheses formulated regarding the dysfunction of the brain. Based on such an evaluation of the patient’s symptoms, specific assessment techniques were developed to test early hypotheses (Luria, 1973). Hence, data resulting from the assessments was not viewed in terms of quantitative norms but instead considered in terms of patterns of “functioning” (Luria, 1973). The techniques used in this approach change from patient to patient as well as for the cerebral function being considered. The flexibility during evaluation seems more indicative of the behavioral neurologist than what we in the West would consider neuropsychological assessment (Dean, 1986). As such, Luria’s strategy is often criticized as employing a far too subjective approach with few opportunities to validate procedures or establish other than clinical norms (Luria, 1973).

In sum, the quantitative school is often portrayed as being atheoretical and ignoring descriptive data, while the more qualitative approach has often been faulted for its reliance on case study methods and a failure to systematically evaluate methods of assessment. In North America, neuropsychological assessment generally involves the administration of standardized test batteries (e.g., *Halstead-Reitan Neuropsychology Test Battery*, 1993; *Luria-Nebraska Neuropsychological Test Battery*, 1985).

The sophistication of radiological diagnostic techniques has increased geometrically in the past 20 years. The new generation of CT scanning equipment, the MRI, and recent advances in positron emission tomography hold clear implications for the diagnosis and localization of neurological disorders. In the past, the noninvasive nature of neuropsychological assessment and the lack of radiological techniques to portray soft tissue made the utility of neuropsychological assessment as a diagnostic tool obvious.

Since the early 1970s, the impact of more sophisticated radiological techniques seems clear. While presently providing criteria for validating neuropsychological diagnostic procedures, continued refinement of radiological procedures will reduce the dependence on neuropsychological assessment in diagnosis and localization of brain damage. As a result, increasing importance has been placed on outlining the functional impairment, as well as defining the adaptive behavior that remains following brain damage (Dean & Gray, 1990). For although definitive knowledge concerning the anatomical integrity of the brain may be available, rarely is the neurologist or neurosurgeon in a position to predict the behavioral expression of a given lesion in the patient's postmorbid environment. Related to brain development, this prediction becomes even less acute.

Similarly, neuropsychological assessment will be influenced by the continuing need to understand the patient's behavioral deficits and planning interventions. Neuropsychological assessment is seen by a number of authors as offering a heuristic framework in which components of the patient's emotional, cognitive, and physical functioning can provide rehabilitation specialists an in-depth view of the patient (Boll, 1976). However, few attempts have been made to interface our present multifunctional measures with rehabilitation strategies.

Summary and Rationale

The history of neuropsychological assessment in North America has involved the use of psychological measures to make differential diagnoses. In such an atheoretical approach, much of the comprehensiveness necessary in understanding the individual patient and planning rehabilitation is lost. Neuropsychological batteries must stress the dynamic interaction between brain function and rehabilitation. An implicit assumption in the past has been that diagnosis or syndrome identification is heuristic enough to allow for differential treatment and to convey an understanding at a functional level. For many neurological diagnoses, little is gained in our appreciation of the individual patient's capacity or, in fact, the patient's needs in rehabilitation planning. From this point of view, the actuarial approach that has characterized neuropsychological assessment in North America is seen as investing itself in the development of standardized batteries to the detriment of understanding the patient's functional capacities.

Because most neuropsychological test batteries are but a collection of tests which have been shown to predict brain damage, the underlying functions measured by these tests are obscure. Indeed, the clinical procedures necessary for data integration have remained a rather mystical procedure for the neophyte. A number of authors have argued that attempts to quantify the interpretative process beyond basic performance statements would do more to confuse the results for the individual patient than to edify (Dean, 1986).

In sum, the future of neuropsychological assessment would seem to rest on the ability to go beyond a simple "brain damage, no damage" decision. However, the test user has few available measures which offer both an unambiguous functional profile and the power to predict diagnostic outcomes. The D-WNAS focuses on empirically derived single function measures, having a theoretical base in present cognitive neuropsychological/information processing theory. This approach departs from the traditional atheoretical approach seen in many of our presently available batteries.

THE DEAN-WOODCOCK COGNITIVE NEUROPSYCHOLOGY MODEL

The assessment of cognitive abilities, or intelligence, is an integral part of the neuropsychological examination. Few modern scholars support the view that intelligence consists of a single broad ability. Such a simplistic notion views intelligence as something like mental height, and the objective of assessment is to measure that height, often as an "IQ." What is the alternative? It is the concept that there are many cognitive abilities (sometimes called multiple intelligences) and further, that these various abilities interact to produce cognitive performance. This issue is important, for one's conceptualization of cognitive ability influences his or her interpretation of an individual's neuropsychological functioning.

The work of Cattell and Horn, known as *Gf-Gc* theory (Horn, 1988, 1991; Woodcock, 1990, 1994), and Carroll's three-stratum theory (Carroll, 1993, 1998) are two prominent, empirically-derived theories of multiple cognitive abilities. Stratum two of Carroll's three-stratum theory and the set of second-order factors described by *Gf-Gc* theory are closely parallel. For the purpose of the D-WNAS, our discussion of cognitive ability will be oriented toward *Gf-Gc* theory.

Figure 1-1 presents the Dean-Woodcock Cognitive Neuropsychology Model. This model has been adapted for neuropsychology from the *Gf-Gc* Information Processing Model (Woodcock, 1993, 1998). It portrays the interaction of various cognitive and noncognitive factors in the production of cognitive and motor performance. An appreciation of the model will aid in interpreting the impact of functional deficits upon the observed performance of a patient. Since the empirical foundation upon which this model rests must be understood before the model itself can be appreciated, an overview of *Gf-Gc* theory is presented next. Following that discussion, we return to the Cognitive Neuropsychology Model and explain it in more detail.

Gf-Gc Theory

Gf-Gc is the acronym for "fluid and crystallized intellectual abilities." Since 1941, Horn-Cattell *Gf-Gc* theory has emerged as a major conceptualization of multiple intelligences. To date, 8 to 10 broad abilities have been consistently identified through factor analysis and replicated in the work of Cattell, Horn, and others. The Dean-Woodcock directly assesses 9 of the 10 broad abilities.

Table 1-1 presents a summary of the nine *Gf-Gc* broad abilities. The symbol or abbreviation following the name of each broad ability is frequently used, but it is not the only notation found in the literature. Somewhat different names may be used from one writer to another and even from one time to another by the same writer.

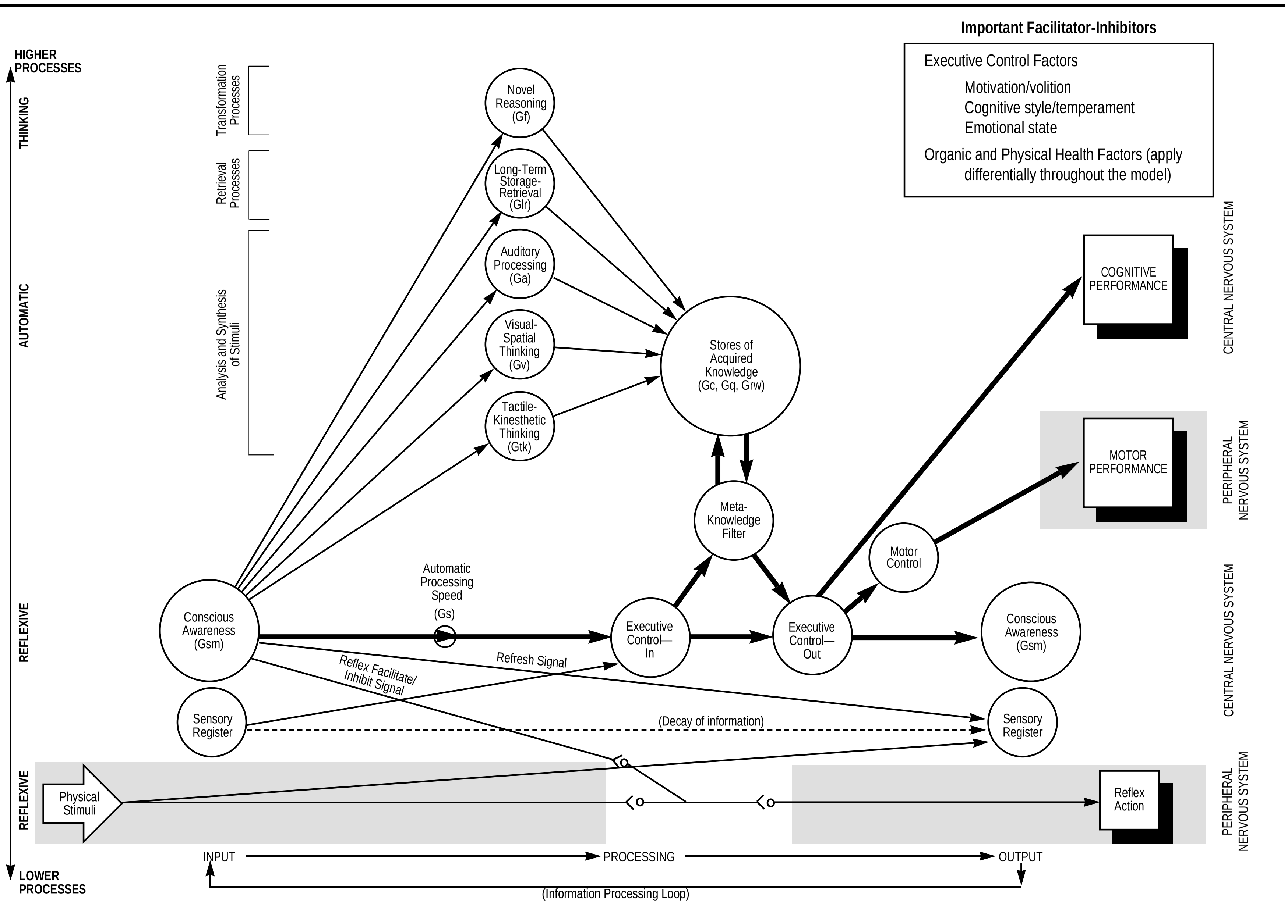

Figure 1-1.
Dean-Woodcock Neuropsychology Model.

Table 1-1.
Nine *Gf-Gc* Broad Abilities

***Gf-Gc* Ability**	**Description**	**Sample Implications of Deficits**
Stores of Acquired Knowledge:		
Verbal Comprehension-Knowledge (*Gc*) Comprensión-Conocimiento	Breadth and depth of knowledge including verbal communication, information, and reasoning when using previously learned procedures.	Lack of information, language skills, and knowledge of non-automatic procedures.
Quantitative Knowledge (*Gq*) Habilidad cuantitativa	Ability to comprehend quantitative concepts and relationships. The facility to manipulate numerical symbols.	Difficulty with arithmetic and other numerical tasks; poor at handling money and making change.
Reading/Writing (*Grw*) Lectura/Escritura	Ability in areas common to both reading and writing. Probably includes basic reading and writing skills, and *skills* required for comprehension and expression. (Not yet well defined in the literature.)	Difficulty with word attack, reading comprehension, or other basic reading skills. Writing is inconsistent and characterized by errors of spelling and usage and of poor expression.
Thinking Abilities:		
Visual-Spatial Thinking (*Gv*) Procesamiento visual	Spatial orientation, ability to analyze and synthesize visual stimuli, and ability to hold and manipulate mental images.	Poor spatial orientation; misperception of object-space relationships; difficulty with art and with using maps; tendency to miss subtle social and interpersonal cues.
Auditory Processing (*Ga*) Procesamiento auditivo	Ability to discriminate, analyze, and synthesize auditory stimuli. Also related to phonemic awareness.	Speech discrimination problems; poor phonological knowledge; failure in recognizing sounds; increased likelihood of misunderstanding complex verbal instructions.
Long-Term Storage-Retrieval (*Glr*) Recuperación a largo plazo	Ability to efficiently store information and retrieve it later.	Difficulty in recalling relevant information and in learning and retrieving names; needs more practice and repetition to learn than peers; inconsistent in remembering previously learned material.
Novel Reasoning (*Gf*) Razonamiento fluido	Ability to reason and solve problems that often involve unfamiliar information or procedures. Manifested in reorganization, transformation, and extrapolation of information.	Difficulty in grasping abstract concepts, generalizing rules, and seeing implications; has difficulty changing strategies if first approach does not work.
Cognitive Efficiency:		
Short-Term Memory (*Gsm*) Memoria a corto plazo	Ability to hold information in conscious or immediate awareness and then use it within a few seconds. Also related to working memory.	Difficulty in remembering just-imparted instructions or information; easily overwhelmed by complex or multistep verbal directions.
Processing Speed (*Gs*) Rapidez en el procesamiento	Speed and efficiency in performing automatic or very simple cognitive tasks.	Slow in execution of easy cognitive tasks; slow acquisition of new material; tendency to become overwhelmed by complex events; need for extra time in responding to even well-practiced tasks.

Important Features of *Gf-Gc* Theory

One feature of *Gf-Gc* theory is that it is not based on any particular battery of tests. Rather, it has been derived from the statistical and logical analysis of hundreds of data sets that include various collections of published and unpublished tests. *Gf-Gc* theory provides a description of what will likely result from an appropriately designed and analyzed factor analysis study (Woodcock, 1990).

Another important feature of *Gf-Gc* theory is its distinction between broad and narrow abilities. (The broad abilities of *Gf-Gc* theory correspond to stratum two in Carroll's three-stratum theory; the narrow abilities correspond to stratum one.) Each of the broad abilities can be measured by a variety of tasks, and each task measures a narrow aspect of the broad ability. For example, verbal comprehension-knowledge (*Gc*) is the factor measured by tests such as vocabulary, general information, geology, or even street-wiseness. Scores from various tests of the same broad ability will show varied patterns of strengths and weaknesses within different individuals. That should not be surprising since few people are equally knowledgeable in areas such as art, history, physics, orchid raising, and sports—all of which are aspects of *Gc*.

The *Gf-Gc* Abilities

Short-Term Memory. Short-term memory (*Gsm*) is a critical component of most cognitive activities. *Gsm* is defined in Table 1-1 as the ability to hold information in conscious or immediate awareness and then use it within a few seconds. A classic example of this ability is remembering a telephone number long enough to dial it. Among the consequences of a short-term memory deficit is difficulty in remembering just-imparted instructions or information. Most available tests of short-term memory measure the span of auditory awareness.

Stores of Acquired Knowledge. The next three *Gf-Gc* abilities represent the stores of declarative and procedural knowledge acquired through schooling and other acculturation experiences. The stores of knowledge include verbal comprehension-knowledge (*Gc*), quantitative knowledge (*Gq*), and reading-writing (*Grw*).

Verbal comprehension-knowledge (*Gc*), called comprehension-knowledge in the WJ-R, represents the breadth and depth of knowledge including verbal communication, information, and reasoning when using previously learned procedures. A patient with a verbal comprehension-knowledge deficit may display a lack of information, language skill, and knowledge of non-automatic procedures.

The second of the stores of acquired knowledge is quantitative knowledge (*Gq*), which is the ability to comprehend quantitative concepts and relationships and to manipulate numerical symbols. Individuals with deficits of quantitative ability display difficulty with numerical tasks.

The third of the stores of acquired knowledge is represented by a common factor underlying both reading and writing. This factor has been designated orthographic ability (*Go*) or reading-writing (*Grw*) (Woodcock, 1998). *Grw* is a factor associated with basic reading and writing skills and the *skills* (not the knowledge) required for comprehension/expression. This factor has not yet been well defined in the literature. Individuals with a *Grw* deficit demonstrate difficulty with reading and writing tasks. Any test involving reading or writing appears to load on this factor in a factor analysis study.

Thinking Abilities. The next four *Gf*-*Gc* abilities to be described are thinking abilities. They include visual-spatial thinking (*Gv*), auditory processing (*Ga*), long-term storage-retrieval (*Glr*), and novel reasoning (*Gf*).

Visual-spatial thinking (*Gv*), called visual processing in the WJ-R, includes spatial orientation and the ability to analyze visual stimuli. Patients with *Gv* deficits may demonstrate poor spatial orientation, misperceived object-space relationships, difficulty with art, and difficulty with using maps.

Auditory processing (*Ga*) is the ability to analyze and synthesize auditory stimuli. This ability does not include understanding of language which is part of verbal comprehension-knowledge (*Gc*). Patients with *Ga* deficits may demonstrate speech discrimination problems, phonemic awareness deficits, and failure in recognizing sounds.

Long-term storage-retrieval (*Glr*), called long-term retrieval in the WJ-R, is the ability to store information and to retrieve it later through association. Note that this ability does not represent the knowledge itself but rather the ability to store and to consciously search for relevant information. For example, if you were asked, “What do people usually wear on their feet?”, you would probably reply promptly with an answer such as, “shoes or socks.” This is an example of direct recall from the *Gc* store of acquired knowledge. If, on the other hand, you were asked, “When was the last time you wore the pair of shoes and socks you are wearing now?”, you may need to think about the question before you could provide an answer. That type of thinking is an example of long-term storage-retrieval. Be aware that in some professional literature the body of stored information is referred to as “long-term memory” or “remote memory.” These terms should not be confused with the thinking ability referred to here as long-term storage-retrieval. Patients with *Glr* deficits may demonstrate difficulty in fluently recalling relevant information and in learning and retrieving names.

Novel reasoning (*Gf*), called fluid reasoning in the WJ-R, is defined as the ability to reason, form concepts, and solve problems that often include unfamiliar situations or procedures. It is manifested in the reorganization, transformation, and extrapolation of information. We often associate *Gf* ability with clever solutions to novel problems. Patients with *Gf* deficits may demonstrate a difficulty in generalizing rules, forming concepts, and seeing implications. *Gf* deficits may also underlie some social/emotional problems.

Processing speed (*Gs*) is the ability to perform automatic or very simple cognitive tasks rapidly. Its role in the cognitive system may be likened to a valve in a water pipe. If the valve is open, flow is at a maximum; if the valve is partially closed, flow is reduced. One consequence of a processing speed deficit is that it takes more time for a patient to complete simple cognitive tasks. Slow *Gs*, however, also exerts a limiting influence on complex task processing by slowing the cycle time, thus decreasing efficiency and increasing time from initiation to completion of a cognitive activity. Most people would obtain nearly perfect scores on a test of processing speed if given enough time. Typical speed tests are further characterized by the examinee being under pressure to maintain focused attention.

Sensory and Motor Functioning. Although not included in traditional discussions of cognitive abilities, there are other stores of knowledge and skills that are important for the assessment of neuropsychological functioning. In fact, the assessment of sensory and motor functions are frequently the initial phase of the neuropsychological examination. The evaluation of basic sensory input and motor output provides information on the integrity of these functions and establishes the patient's ability to reliably participate in tests of higher abilities represented in Figure 1-1. In fact, sensorimotor functions have been shown to have a powerful relationship to a broad range of human adaptive abilities (Hom & Reitan, 1984).

Facilitator-Inhibitors

Facilitator-inhibitors influence cognitive performance for better or for worse, often overriding strengths or weaknesses in short-term memory, acquired knowledge, or the thinking abilities. Facilitator-inhibitors include a host of internal and external forces that impact an individual's cognitive performance. For instance, general health, if it is good, should have a favorable impact on performance; if it is poor, the impact is unfavorable. Motivation, or volition, is an important facilitator-inhibitor. If an individual is interested in the task, this is favorable; if the individual is indifferent to the task, then cognitive performance may suffer. Impulse control is another important facilitator-inhibitor. Some individuals are careful and thoughtful in their responses, while others are impulsive.

The majority of facilitator-inhibitors have a direct impact on attention. Indeed, functions of the sensory register, executive control, and immediate awareness depend upon attention. Attention facilitates orientation, concentration, and vigilance. Impaired attention inhibits most cognitive processing. Problems with attention are clearly related to distractibility, impersistence, and, at an extreme level, confusion (Luria, 1963). Attention may be viewed as the foundation of a measure designed to assess sensory-motor functions as well as higher level cognitive functions such as memory and construction.

From this point of view, it becomes clear that affect, arousal, wakefulness, and motivation may facilitate or inhibit attention, thereby impacting neuropsychological functioning. Impaired attention may be either primary, secondary, or a combination of both. For example, an Attention Deficit Disorder with symptoms of inattention, distractibility, and impulsivity may be seen as a primary disorder of attention (Cantwell, 1996). For patients in which emotional factors dominate the clinical picture, affective and physical features such as anxiety, depression, confusion, ill health, and/or medication may be responsible for secondary inattention. While impairments to attention are secondary to these symptoms, they have no less an impact upon neuropsychological functioning (Cantwell, 1996). In sum, attention should be considered a necessary but not a sufficient prerequisite of cognitive performance.

Description of the Cognitive Neuropsychology Model

One intent of most models is to provide a simplified representation of the relationships among the components of a complex process. Though there may be some correlation, a model of cognition does not necessarily represent the underlying physical components and their connections. The Dean-Woodcock Cognitive Neuropsychology Model, Figure 1-1, was derived from combining *Gf-Gc* theory with information processing theory. The model will be presented here in a stepwise manner to aid the reader in its application. Before reading the explanation, however, the reader should consider certain features of the model.

1. The model in Figure 1-1 indicates whether a process or pathway involves the peripheral nervous system, the central nervous system, or both.
2. The arrow in the lower left-hand corner of Figure 1-1 represents the input of physical stimuli from external or internal sources.
3. The right-hand, or output, side of the model includes cognitive and motor outcomes.
4. The horizontal dimension of Figure 1-1 represents a single cycle of cognitive processing including input, processing, and output. The right-hand, or output, side of the model serves as the input for the next cycle. (The model may be perceived as being wrapped into a cylinder with the output of one cycle becoming the input for the next cycle.)
5. The vertical dimension of the model represents the level of cognitive processing. Reflexive processes are represented in the lowest portion of the model. Above this level the automatic processes are represented. The upper region of the model includes the thinking and reasoning processes.
6. The model recognizes that cognitive and motor performance is not determined by cognitive abilities alone but also by the influence of noncognitive factors, called facilitator-inhibitors.

Although this model may appear complex at first, reading the following section will provide an appreciation of how cognitive and noncognitive influences interact to produce cognitive and motor performance. This, in turn, may contribute to a more insightful interpretation of neuropsychological information.

Reflexive Level

The lowest level in the cognitive neuropsychology model represents one of the most fundamental neurological functions—the reflex arc (Figure 1-2). For example, if you unexpectedly touch a very hot object (physical stimuli), your response will be a rapid retraction of the hand. This reflexive action is represented in Figure 1-2 by the line extending from physical stimuli to reflex action. Note that the reception of physical stimuli and motor response are located in the peripheral nervous system but that part of the reflex arc takes place in the spinal cord portion of the central nervous system. The protective reflex action occurs quickly, even before there is any conscious awareness of heat or pain.

While the reflex action is underway, a signal is traveling to the appropriate sensory register in the brain (Figure 1-3). Recall that since the horizontal dimension of the model represents only a single cycle of functioning, the

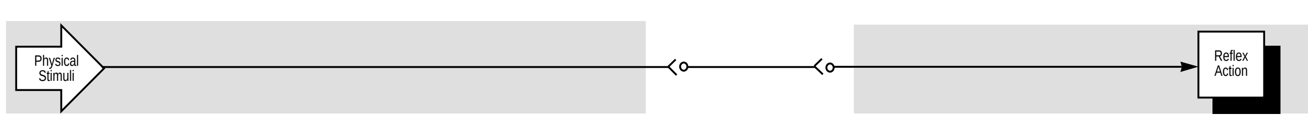

Figure 1-2.
Reflexive level of the cognitive neuropsychology system.

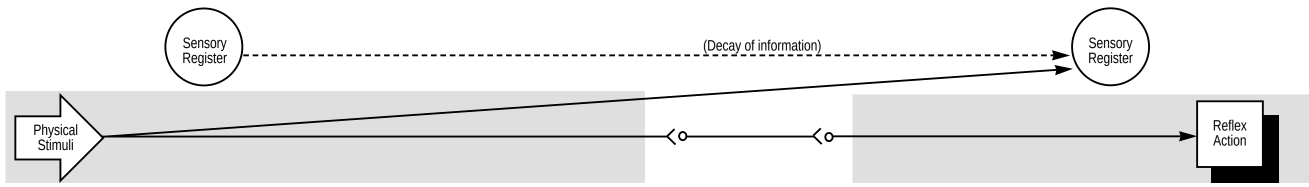

Figure 1-3.
Input to sensory registers.

contents of the sensory register on the right side of the model are simultaneously acting upon the contents of the sensory register represented on the left side. The dotted line between the sensory register on the left and the sensory register on the right indicates that the sensory information will rapidly decay if there is no further input.

Figure 1-4 introduces the concept of conscious awareness onto Figure 1-3. The information that has reached the sensory register is routed through executive control into conscious awareness. You are now aware of having touched the hot object. Executive control operates as a traffic director in the cognitive system, allocating attentional resources, directing automatic and non-automatic activity, and monitoring operations. Though it is in the stream of conscious awareness, executive control usually performs its responsibilities automatically.

Conscious awareness, in concert with executive control, can exercise limited control over some reflex and sensory registers (Figure 1-5). At least four types of controlling actions may be initiated from conscious awareness. First, an inhibit signal can moderate the normal action of the reflex arc. For example, if one must pick up an object that is suspected of being hot, conscious awareness can suppress operation of the reflex arc and allow the object to be picked up even though it is painful. Second, a facilitate signal to the reflex arc can enhance its proclivity to initiate a reflex action even if the object is only slightly warm. The third controlling action can signal the sensory register to recycle its stored information through conscious awareness, a type of review process that is only available for a second or two. For example, if a sound is not immediately recognized, conscious awareness may transmit a refresh signal to the sensory register and its contents can be

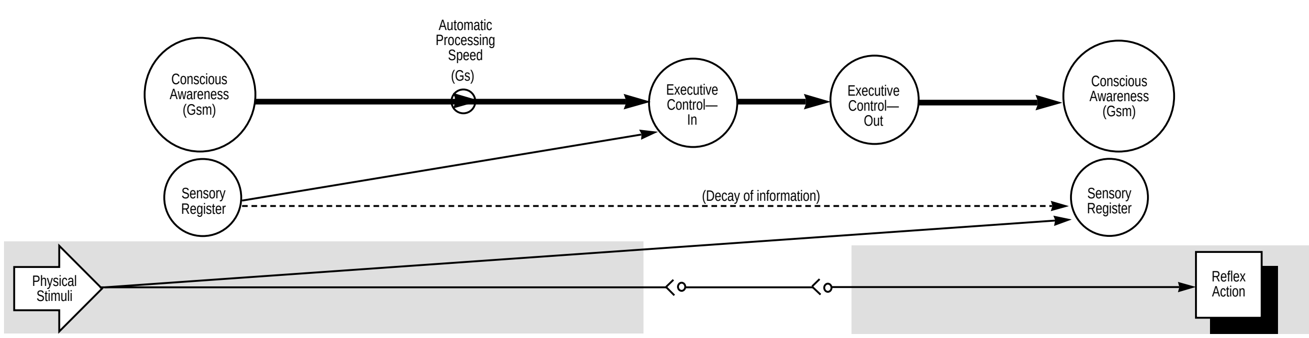

Figure 1-4.
Automatic level of the cognitive neuropsychology model.

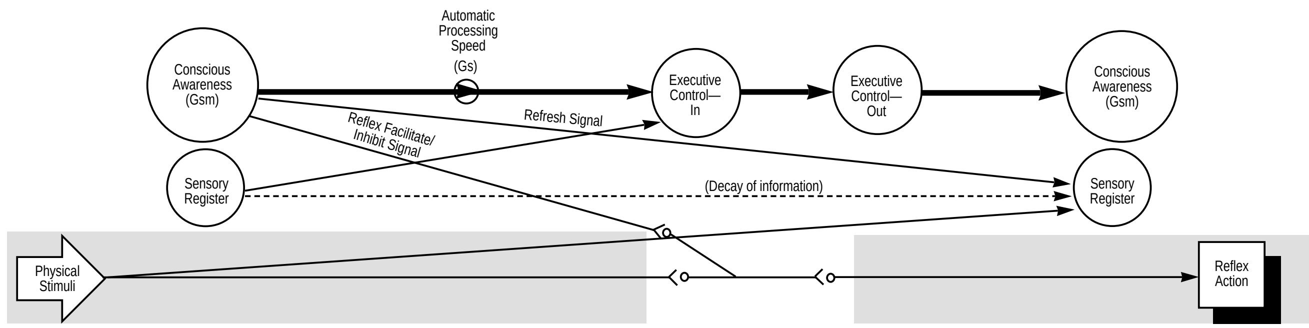

Figure 1-5.
Influence of conscious awareness upon reflex arcs and sensory registers.

sent again into conscious awareness, thus providing a short-lived opportunity to "rehear" the sound. A similar function of the refresh signal facilitates the rehearsal of auditory stimuli. If the stimuli is a telephone number that you must remember long enough to dial, the refresh signal allows you to rehearse that number. Woodcock (1993) refers to this process as the "phonological loop." The fourth type of controlling action allows conscious awareness to attend to the contents of sensory registers that are being ignored, such as the pressure being exerted on your feet by the shoes you are wearing.

Note that the path from conscious awareness through executive control, and to certain other areas in the complete model, is represented by a broad line indicating that this is the "freeway" of cognitive functioning. Most of the activity at this level is automatic. Two *Gf-Gc* broad abilities, short-term memory (*Gsm*) and automatic processing speed (*Gs*), and certain facilitator-

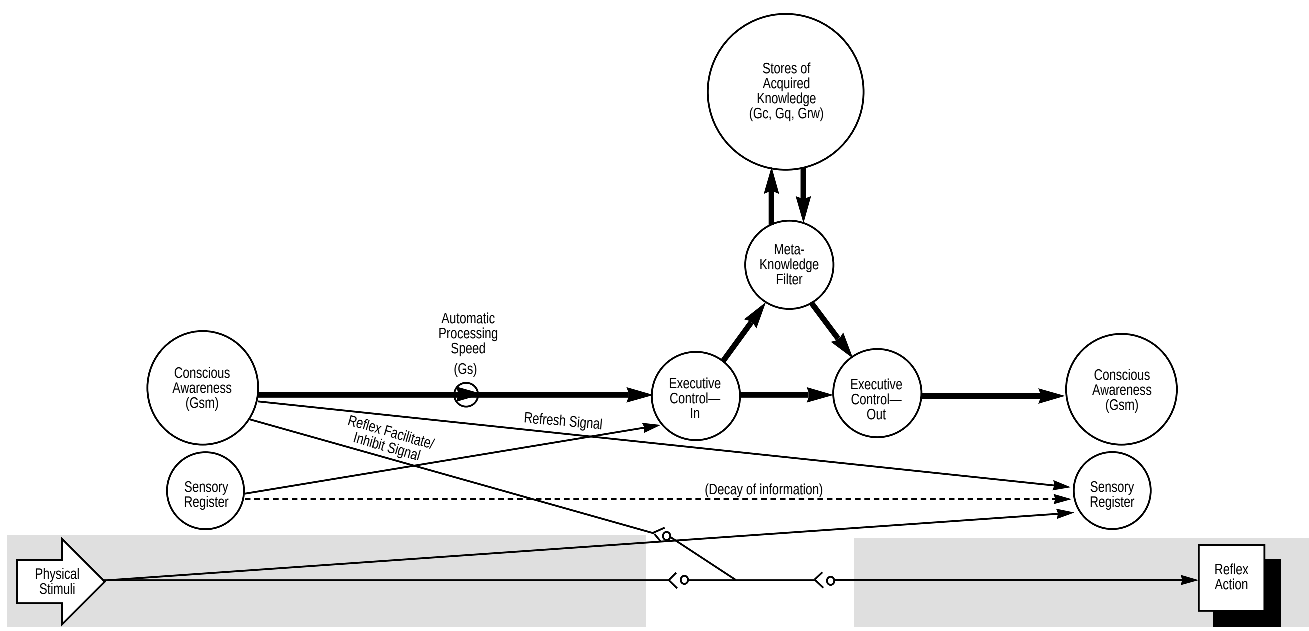

Figure 1-6.
The metaknowledge filter and stores of acquired knowledge.

inhibitors play important roles along this freeway. These abilities reflect the individual's capacity to hold information in conscious awareness and to perform automatic tasks rapidly. If the individual has a processing speed limitation, this operates as if a partially closed valve is reducing the flow of information along the automatic pathway.

Figure 1-6 adds a large circle to the model that represents the stores of declarative and procedural knowledge. In the pathway between executive control and these stores of knowledge lies the metaknowledge filter. This portion of the model decides, more or less imperfectly, whether the declarative and/or procedural knowledge is known and available. If not, executive control may generate a strategy for attempting to solve the problem. The model now allows for the recognition of familiar stimuli, such as your name when you are called or the face of a friend.

Figure 1-7 adds the components of cognitive performance (a central nervous system function) and motor performance (both a central and peripheral nervous system function) to the model. Note that motor performance is moderated by motor control which is part of the central nervous system. If you wish to write down a telephone number that is currently in conscious awareness, those pathways would be involved.

Now suppose the stimulus was the question, "How do you spell your name?" We have already described the path that this stimulus (the question) would follow from the arrow representing physical stimuli into conscious awareness with executive control operating as a traffic director. The question, "How do you spell your name?", is routed through the metaknowledge filter by executive control into the stores of knowledge. Assuming that the individual knows how to spell his or her name, the

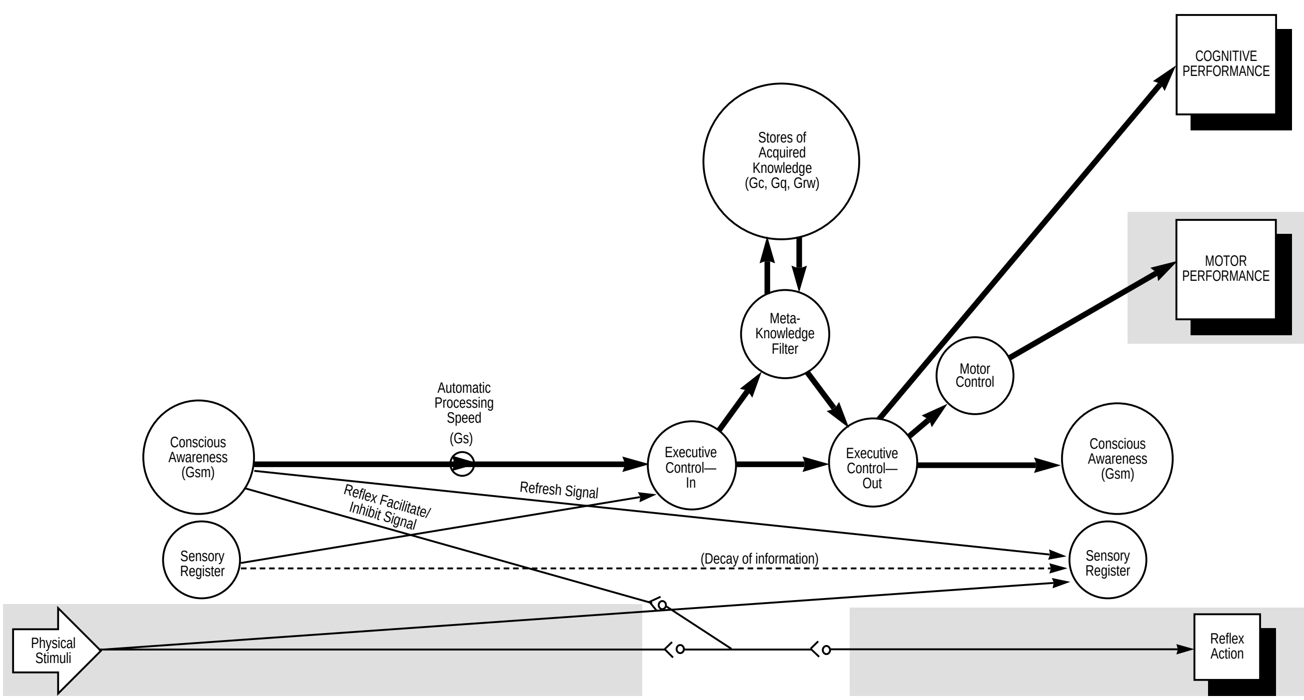

Figure 1-7.
Cognitive performance and motor performance components of the cognitive neuropsychology model.

retrieval of the spelling is automatic. Upon returning to executive control, the output goes to cognitive performance and to a motor representation in either speech or writing. Of course, if the individual has not learned to spell his or her name, there is no store of that knowledge and the individual could not provide a correct response.

Note that the stores of acquired knowledge include three of the previously described *Gf*-*Gc* abilities, verbal comprehension-knowledge (*Gc*), quantitative knowledge (*Gq*), and reading-writing (*Grw*). In addition, though not normally included in discussions about *Gf*-*Gc* theory, various sensory and motor knowledge stores could be added to the model.

Now suppose the stimulus (question) has changed and you are asked to spell your name backward. (As a personal experiment, try it!) The response no longer requires a simple automatic recall from stored knowledge but, rather, you must think. Figure 1-8 adds the thinking abilities to the Cognitive Neuropsychology Model. These include the traditional *Gf*-*Gc* abilities of visual-spatial thinking (*Gv*), auditory processing (*Ga*), long-term storage- retrieval (*Glr*), and novel reasoning (*Gf*). Neuropsychologists are also concerned with other types of processing, particularly motor, tactile, and kinesthetic (*Gtk*). Such processing represents a complex interaction of cortical and subcortical functions as well as pathways in the spinal cord and the peripheral nervous system.

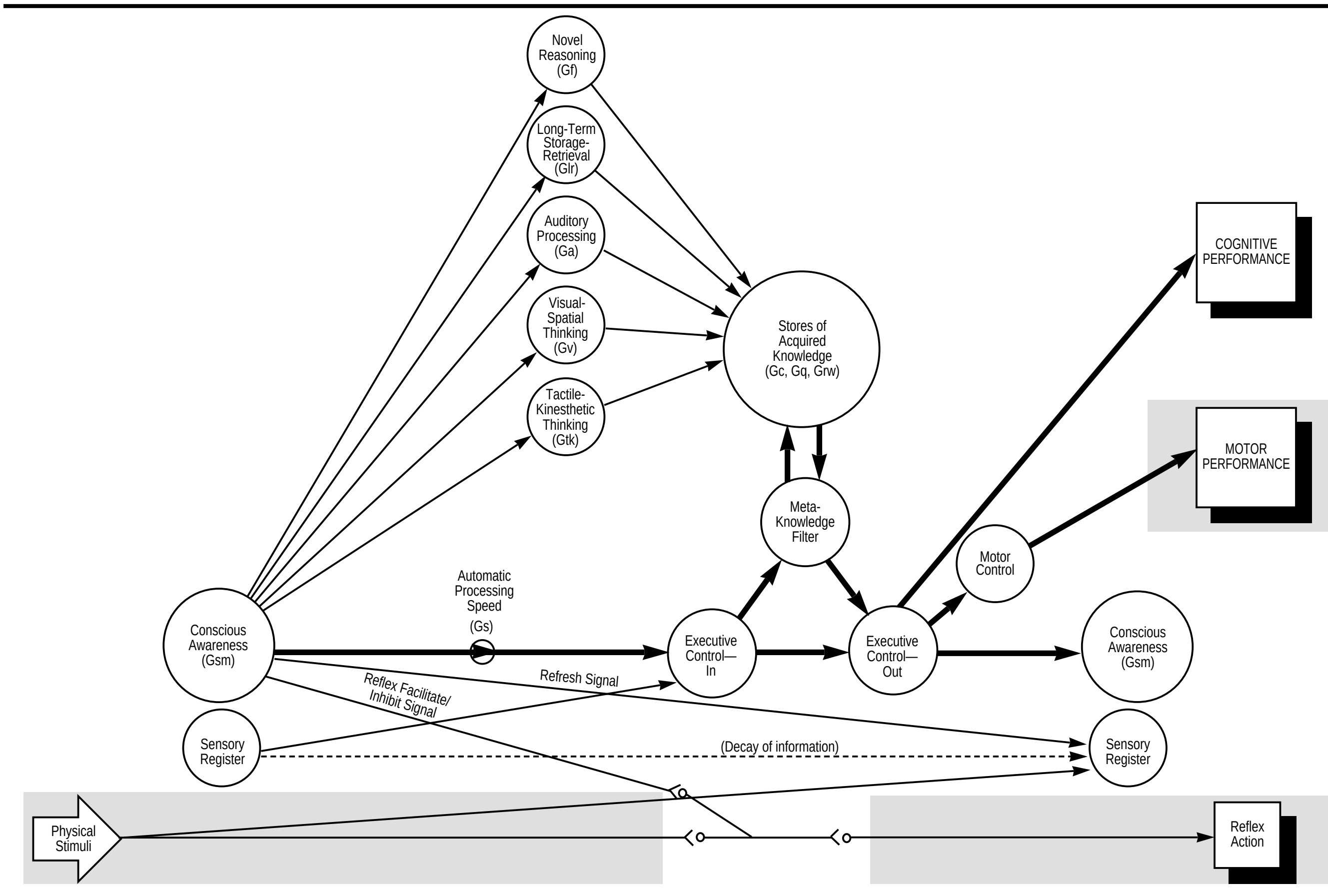

Figure 1-8.
The thinking abilities added to the cognitive neuropsychology model.

Since you have probably never attempted to spell your name backward, there is no chunk of stored knowledge from which to draw. As a result, your cognitive system must produce a strategy for attacking that problem. That strategy, along with the question, enters conscious awareness. Most people attack this problem by visualizing their name in the "mind's eye" and then spelling it backward. As this process is executed, the result flows through the stores of knowledge, through executive control, and on to cognitive and motor performance. The reversed spelling of your name, on its way through the stores of knowledge, leaves a trace in the memory systems. If this process is repeated enough times, that trace grows and becomes part of stored knowledge. Subsequently, at the request to spell your name backward, that information can be retrieved automatically and reported without invoking the previously required thinking process.

At this point, except for the facilitator-inhibitors, we are now back to the complete Cognitive Neuropsychology Model as represented in Figure 1-1. Note the box in the upper right-hand corner of Figure 1-1. That box lists some of the facilitator-inhibitors that can exert a profound influence on cognitive and motor performance. Facilitator-inhibitors primarily operate on executive control in this model and include, for example, motivation/volition, cognitive style, temperament, or emotional state. In addition, various organic factors operate as facilitator-inhibitors and apply differentially throughout the model. The input of physical stimuli may be especially impacted by organic factors such as impaired vision or hearing.

This completes the description of the Cognitive Neuropsychology Model, but two caveats are in order. First, as complex as this model may appear, it is an over-simplification of the neurological bases of cognitive processing. Most cognitive processing requires interaction of many components and, further, requires many cycles for completion. Second, the model represents functional relationships among the components and there is not necessarily specific neuroanatomical correspondence that can be said to underlie a particular component or pathway.

The sections which follow offer recent data from the WJ-R and the D-WSMB with a number of clinical populations. In each case, an attempt is made to integrate individual components of the model with our knowledge of neuroanatomical functioning and individual tests. The last section of this report offers a number of case studies which detail the use of the Cognitive Neuropsychological Model in functional appraisal of individual patients.

Section II: Components of the Neuropsychological Assessment System

The *Dean-Woodcock Neuropsychological Assessment System* (D-WNAS) (Dean and Woodcock, in preparation) is designed to be interpreted on at least two levels, depending on the training of the examiner and the intended use of the test results. As Boll (1987) and others have pointed out, a neuropsychological assessment offers the most complete psychological picture of a subject possible. Indeed, the neuropsychological battery includes measures of cognitive, sensory-motor, and emotional status. From this point of view, interpretation of the D-WNAS may be accomplished at an information processing or functional level consistent with the *Gf-Gc* model. A second level of interpretation includes a consideration of the neurological implications of a subject's performance.

This section provides an introduction to the components of the D-WNAS. The *WJ-R Tests of Cognitive Ability* (WJ-R COG) (Woodcock & Johnson, 1989b) and the *WJ-R Tests of Achievement* (WJ-R ACH) (Woodcock & Johnson, 1989a) are the core of the Cognitive Neuropsychological Model. The *Dean-Woodcock Sensory Motor Battery* (D-WSMB) and the *Dean-Woodcock Structured Interview and Mental Status Exam* round out assessment of the functions shown in Figure 1-1. In addition, the *Structured Interview and Mental Status Exam* assesses the facilitator-inhibitors which may influence neuropsychological functioning.

Overview of WJ-R Batteries

The WJ-R is a wide-range, comprehensive battery of individually administered tests measuring cognitive abilities and achievement. It is composed of two major parts: the *WJ-R Tests of Cognitive Ability* and the *WJ-R Tests of Achievement*. Both parts are further subdivided into a Standard Battery and a Supplemental Battery. Depending on the purpose and extent of the assessment, the Standard Batteries of the WJ-R COG and WJ-R ACH may be used alone or in conjunction with tests from the Supplemental Batteries. The *Batería Woodcock-Muñoz: Pruebas de habilidad cognitiva–Revisada* (Batería-R) (Woodcock & Muñoz-Sandoval, 1996b) and the *Batería Woodcock-Muñoz: Pruebas de aprovechamiento–Revisada* (Woodcock & Muñoz-Sandoval, 1996a) are direct Spanish-language counterparts to the WJ-R.

Many neuropsychology batteries are a collection of separate tests. They often have norms for individual tests collected at different dates and with different subjects. This introduces significant problems when a comparison of scores across the tests is attempted. Moreover, discrepant scores from different tests may reveal more about the differences in the tests than about intra-individual functional differences for the individual patient. The WJ-R tests provide a comprehensive functional appraisal of the patient with all facets, integrated by a common set of norms. Indeed, the normative data for all tests are based upon a nationally standardized sample of 6,359 subjects, aged 24 months to 90 years of age. A complete list of the 39 WJ-R COG and the WJ-R ACH tests are presented in Table 2-1. The names of the tests in the counterpart Batería-R are also included in Table 2-1. Notations indicate those

Table 2-1.
The 39 WJ-R/Batería-R Tests

	Tests of Cognitive Ability
	Standard Battery:
1	Memory for Names (E Dev) Memoria para nombres
2	Memory for Sentences (E Dev) (T) Memoria para frases
3	Visual Matching Pareo visual
4	Incomplete Words (E Dev) (T) Palabras incompletas
5	Visual Closure (E Dev) Integración visual
6	Picture Vocabulary (E Dev) Vocabulario sobre dibujos
7	Analysis-Synthesis Análisis-Síntesis
	Supplemental Battery:
8	Visual-Auditory Learning (E Dev) Aprendizaje visual-auditivo
9	Memory for Words (E Dev) (T) Memoria para palabras
10	Cross Out Tachar
11	Sound Blending (E Dev) (T) Integración de sonidos
12	Picture Recognition (E Dev) Reconocimiento de dibujos
13	Oral Vocabulary Vocabulario oral
14	Concept Formation Formación de conceptos
15	Delayed Recall—Memory for Names Memoria diferida—Memoria para nombres
16	Delayed Recall—Visual-Auditory Learning Memoria diferida—Aprendizaje visual-auditivo
17	Numbers Reversed (T) Inversión de números
18	Sound Patterns (T) Configuración de sonidos
19	Spatial Relations Relaciones espaciales
20	Listening Comprehension (T) Comprensión de oraciones
21	Verbal Analogies Analogías verbales

	Tests of Achievement
	Standard Battery:
22	Letter-Word Identification (E Dev) Identificación de letras y palabras
23	Passage Comprehension Comprensión de textos
24	Calculation Cálculo
25	Applied Problems (E Dev) Problemas aplicados
26	Dictation (E Dev) Dictado
27	Writing Samples Muestras de redacción
28	Science (E Dev) Ciencia
29	Social Studies (E Dev) Estudios sociales
30	Humanities (E Dev) Humanidades
	Supplemental Battery:
31	Word Attack Análisis de palabras
32	Reading Vocabulary Vocabulario de lectura
33	Quantitative Concepts Conceptos cuantitativos
34	Proofing Corrección de textos
35	Writing Fluency Fluidez en la redacción
P	Punctuation Puntuación y Mayúsculas
S	Spelling Ortografía
U	Usage Concordancia
H	Handwriting Escritura

(E Dev) *= test suitable for use as an early development measure.*
(T) *= tape-recorded test.*

tests that are especially suited as early developmental measures and those that are administered with an audio recording.

Development

A final note should be made with respect to *Gf-Gc* theory and the model underlying the WJ-R. An earlier section of this report offered an overview of the present status of the theory and model. As future data and theory point the way, the *Gf-Gc* theory will be subject to change, most likely by the definition of more factors. The D-WNAS model is based upon current evidence. Empirical support for the model with clinical populations will follow in this report. Measurement procedures were designed to ensure high technical quality. Throughout the development and design of the WJ-R, concepts of latent-trait theory and the analysis of data by the Rasch model were employed (Rasch, 1960; Wright & Stone, 1979). Thus, the technical criteria for item selection were quite stringent since retained items had to fit the Rasch model as well as meet other criteria.

The number of items in each WJ-R test was set so that a reliability of .80 or higher would usually be obtained. The goal for cluster score reliabilities was set at .90 or higher. The reliability and validity of the tests was enhanced by the use of open-ended or free-response questions rather than multiple-choice questions. A multiple-choice format not only would have had no particular advantage, since the WJ-R is intended for individual administration, but also would have resulted in lower reliability for a test with the same number of items. In addition, free-response questions allow observation of the patients and clinical evaluation of responses.

The use of the cluster concept, in which the results from two or more tests are combined to measure a broad ability, provides a unique basis for neuropsychological test interpretation. The principle of cluster interpretation minimizes the danger of generalizing from a single narrow aspect of behavior, such as oral receptive vocabulary, to a broad multifaceted ability, such as cognitive ability. Thus, in the WJ-R, the validity of the interpretations of broad abilities is increased because more than one component of a broad skill is represented in the score.

Table 2-2 presents the 25 WJ-R clusters and the individual tests comprising these clusters. The name of the clusters in the Spanish language Batería-R are also included in Table 2-2. Technical consideration of both individual tests and clusters are important in understanding a patient's neuropsychological functioning.

Interpretation—Focused Norms

A unique aspect of the D-WNAS is the availability of focused norms that adjust WJ-R scores for age, education and gender. The Focused Norms Calculator (FNC) has been developed especially for use in neuropsychological applications of the WJ-R. Thus, certain demographics (age, education, and gender) for individual patients can be taken into account when classifying patients as "normal" or impaired (mild, moderate, or severe). The procedure allows the patient's performance to be compared to all others of the same age, education, and gender in the norming sample. The conventional application of norms only compares an individual to all others of the same age. In order to use the FNC, it is necessary to first obtain age-based standard scores from

Table 2-2.
Description of the WJ-R/Batería-R Clusters

Cluster Name	Cluster Composition
Cognitive Clusters: Broad Cognitive Ability (BCA) Habilidad cognitiva amplia (BCA)	
Early Development Scale Escala de desarrollo temprano	Tests 1, 2, 4, 5, and 6
Standard Scale Escala estándar	Tests 1 to 7
Extended Scale Escala extendida	Tests 1 to 14
Cognitive Factors:	
Long-Term Retrieval (*Glr*) Recuperación a largo plazo	Tests 1 and 8
Short-Term Memory (*Gsm*) Memoria a corto plazo	Tests 2 and 9
Processing Speed (*Gs*) Rapidez en el procesamiento	Tests 3 and 10
Auditory Processing (*Ga*) Procesamiento auditivo	Tests 4 and 11
Visual Processing (*Gv*) Procesamiento visual	Tests 5 and 12
Comprehension-Knowledge (*Gc*) Comprensión-Conocimiento	Tests 6 and 13
Fluid Processing (*Gf*) Procesamiento fluido	Tests 7 and 14
Scholastic Aptitude:	
Reading Aptitude Aptitud en lectura	Tests 2, 3, 11, and 13
Mathematics Aptitude Aptitud en matemáticas	Tests 3, 7, 13, and 14
Written Language Aptitude Aptitud en lenguaje escrito	Tests 3, 8, 11, and 13
Knowledge Aptitude Aptitud en conocimiento	Tests 2, 5, 11, and 14
Oral Language:	
Oral Language Lenguaje oral	Tests 2, 6, 13, 20, and 21
Oral Language Aptitude Aptitude en lenguaje oral	Tests 12, 14, 17, and 18
Academic Achievement Clusters:	
Broad Reading Amplia lectura	Tests 22 and 23
Basic Reading Skills Destrezas básicas en lectura	Tests 22 and 31
Reading Comprehension Compresión de lectura	Tests 23 and 32

Table 2-2, cont.

Cluster Name	Cluster Composition
Broad Mathematics Amplias matemáticas	Tests 24 and 25
Basic Mathematics Skills Destrezas básicas en matemáticas	Tests 24 and 33
Mathematics Reasoning Razonamiento en matemáticas	Test 25
Broad Written Language Amplio lenguaje escrito	Tests 26 and 27
Basic Writing Skills Destrezas básicas en escritura	Tests 26 and 34
Written Expression Expresión escrita	Tests 27 and 35
Broad Knowledge Amplio conocimiento	Tests 28, 29, and 30
Skills Destrezas	Tests 22, 25, and 26

the WJ-R following the usual procedure. To obtain focused norms, these age-based standard scores are entered into the FNC program along with information about the patient's age, education, and gender.

The impact of age and years of education upon standard scores is quite clear with an examination of Table 2-3. For the purpose of Table 2-3 it is assumed that the example subjects all had age-based standard scores of 100 following the traditional procedure for scoring the WJ-R. If a 50-year-old with 8 years of education received a WJ-R standard score of 100 for BCA, the adjusted standard score would be 116, meaning that his performance was +1.09 standard deviations *above* the average performance of other 50-year-old subjects with 8 years of education. However, if the patient were a college graduate (16 years of education) and had received the same WJ-R standard score of 100, the adjusted score would be 90, or –0.65 standard deviations *below* the average for other 50-year-olds with 16 years of education. Other examples in Table 2-3 include two 10-year-old girls, one in grade 3.7 and the

Table 2-3.
Focused Norms Calculator Results for Four Subjects

Age	Grade Placement	Years of Education Completed	Gender	WJ-R Cluster[1]	WJ-R Standard Score	Focused z Score	Focused Standard Score
10-0	3.7	2.7	F	BCA	100	+0.32	105
10-0	3.7	2.7	F	WrtLang	100	+0.45	107
10-0	5.7	4.7	F	BCA	100	–0.58	91
10-0	5.7	4.7	F	WrtLang	100	–0.79	88
50	—	8	M	BCA	100	+1.09	116
50	—	8	M	WrtLang	100	+1.42	121
50	—	16	M	BCA	100	–0.65	90
50	—	16	M	WrtLang	100	–0.80	88

[1] *BCA is Broad Cognitive Ability (Extended). WrtLang is Broad Written Language.*

other in grade 5.7. These examples are somewhat extreme; however, patients with such variability are quite common in clinical practice.

Another feature that increases the value of the FNC is that the norms for all WJ-R cognitive and achievement tests and clusters are based on the same sample of individuals. This allows the user to evaluate a patient's individual differences across a wide spectrum of functions while controlling for age, education and gender. This, again, improves upon the less precise nature of traditional neuropsychological assessment. The "Functional Level/Deficit Descriptions" table (Table 3-9 in section III) offers labels useful in reporting levels of deficit or preserved function. These labels are a modification of the verbal labels recommended in the *WJ-R Examiner's Manuals* for general use and are more appropriate for clinical work when used in conjunction with the Focused Norm Calculator.

Overview of the *Dean-Woodcock Sensory Motor Battery*

The *Dean-Woodcock Sensory Motor Battery* (D-WSMB) (Dean & Woodcock, in preparation) was designed to offer a comprehensive group of tests which compliment the functions measured by the WJ-R in neuropsychological assessment. As the name would imply, the battery is comprised of two major sections—Sensory and Motor. The Sensory section consists of nine tests which evaluate simple and complex visual, auditory, and tactile perception. Motor functions are assessed with nine individual tests. Three of the measures are standardized adaptations of neurological tests of subcortical functioning. The six remaining motor tests are predominantly meant to measure motor functioning at the cortical level. The assessment of subcortical motor functions is important because impairment at this level may often mimic cortical dysfunction. Table 2-4 presents an overview of each of the tests and the functions measured. To aid in interpretation, behavioral overviews are provided with the test instructions to allow the classification of the patient as normal or mildly, moderately, or severely impaired. In addition, the tests include Spanish language instructions.

A number of specific inferential techniques have evolved in the interpretation of neuropsychological assessment findings (Reitan, 1974). They include level of performance, left-right differences, pathological signs, and complex pattern analyses. The first focuses on the patient's "level of performance" on measures of individual abilities. Using normative data as a standard, "cut-off scores" indicative of either aberrant functioning or of normal performance are compared with the patient's results. Although low levels of functioning are suggestive, they are rarely sufficient for inferring cortical dysfunction. Congruent with research outlining the cerebral lateralization of brain function, the patient's left-right hemispheric abilities are compared (Reitan, 1974). So too, the functional efficiency of the left and right sides of the body with regard to sensory perception and motoric functions are examined in a systematic fashion. These data are often grouped into behavior constellations which may be compared with signs of neuropathology. Thus, sensory-motor symptoms that rarely would be displayed in a patient without the presence of neurological dysfunction can be isolated. These signs of cerebral dysfunction reflect a combination of symptoms which have been shown to have diagnostic significance. The segmental (or pathological) sign approach has been shown to make mistakes in the conservative direction

Table 2-4.
Tests of Sensory Motor Battery and Functions Measured

Subtest	Functions or Symptoms Assessed
Sensory Tests	
Lateral Preference Scale	Assesses laterality.
Near Point Visual Acuity	Screens for visual acuity.
Visual Confrontation	Examines for peripheral visual field deficits.
Naming Pictures of Objects	Screens for features of dysnomic aphasia, visual dysgnosia for drawings, and color anomia.
Auditory Perception	Examines elements of vestibular and acoustic functions.
Tactile Examination	
Palm Writing	Examines sensory functioning associated with graphesthesia.
Object Identification	Screens for symptoms of astereognosia.
Finger Identification	Sensitive to errors associated with asomatognosia and tactile projection.
Simultaneous Localization (Hands Only and Hand/Cheek)	Assesses positive signs of asomatognosia, tactile projection, and right-left confusion.
Motor Tests (Subcortical)	
Gait and Station	Assesses peripheral and central nervous system functioning, screening for ataxia, muscular weakness, and spasticity.
Romberg Test	Screens for unsteadiness associated with cerebellar or vestibular dysfunction.
Coordination Test (Finger to Nose and Hand/Thigh)	Examines gross motor coordination and screens for symptoms associated with ataxia, dyskinesia, and myoclonic jerks
Motor Tests (Cortical)	
Construction Test (Cross and Clock)	Assesses visuoconstructive ability or constructional paraxis.
Mime Movements	Considers ideomotor functioning and signs of auditory vernal agnosia and ideokinetic apraxia.
Left-Right Movements	Screens for left-right confusion including errors or perseveration and awkwardness.
Finger Tapping	Measures manual dexterity of upper extremities.
Expressive Speech	Assesses signs of dysarthria.
Grip Strength	Measures strength of upper extremities.

(false negatives). Therefore, a positive diagnosis inferred from the Sensory Motor Battery is far more informative than a negative finding.

Pattern analysis is an integration of the level of performance, lateralization techniques, and segmental signs. This approach has successfully been applied to data resulting from the neuropsychological evaluation.

Reliability and Validity

The D-WSMB is a collection of tests drawn primarily from the traditional neurological examination to provide comprehensive coverage of basic sensory and motor functions, most of which have pathognomonic significance. Although used routinely across a variety of settings, pathognomonic signs have received little attention in terms of basic test development (Buchanan & Heinrichs, 1989).

Recently using the D-WSMB, Woodward, Ridenour, and Dean (in preparation) gathered data to consider the incidence of pathognomonic signs in a normal adult population, to identify items of the battery with difficulty levels which might lead to overidentification of signs of abnormality (i.e., false positives) and to estimate the reliability. Characteristics such as scale of measurement, number of items, independence of items, objectivity of item categories, item discrimination, internal consistency, interrater reliability, and/or interrater agreement was estimated for each test. Interrater reliability and interrater agreement have been distinguished respectively as consistency in maintaining rank order and proportion of agreement (Franzen, 1989; Pedhazur & Schmelkin, 1991). Data analysis in the present study reflects consideration of Franzen's argument that because reliability is an abstract concept, it can be more completely understood through the use of multiple estimation strategies. Further, Cicchetti's (1988, p. 621) call for the examination of data at "finer levels of molecular analysis" was addressed.

Woodward et al. (in preparation) evaluated the reliability and validity of the battery with 105 normal subjects between the ages of 19 and 79 years (M = 38.43). In preparation for large-scale collection of data, the tests of the D-WSMB were examined for item heterogeneity likely to result in false positive decisions and to estimate the agreement and reliability of independent ratings requiring judgemental processes. The latter is particularly important when raters are called upon to make subtle discriminations such as are necessary for many motor tests.

Sensory Assessment. Estimates of the incidence of pathognomonic signs in the normal population have ranged from 5% to greater that 50% (Buchanan & Heinrichs, 1989). Results of the measures of basic visual and auditory perception were consistent with the lower end of that range. Greater consistency between the proportions of the sample demonstrating errors on Visual Confrontation and Auditory Perception was found when participants over the age of 70 were deleted. This argues for stratified sampling when collecting normative data on these basic sensory functions. On the Finger Identification and Simultaneous Localization tests, which reflect basic tactile perception, the proportion of the sample demonstrating errors was identical (12.63%). A review of the data from these two tests revealed no apparent relation to subject age.

Future investigation of the Visual Confrontation, Auditory Perception, Finger Identification, and Simultaneous Localization tests, all of which consist of a set random series of a restricted number of stimuli delivered with minimal intensity, should focus on interexaminer and test-retest reliabilities. The fact that all errors on the Simultaneous Localization test were of hand when presented simultaneously with face is consistent with earlier results implicating a rostral dominance effect (Bender, 1952; Kolb & Whishaw, 1990) and is worthy of further investigation.

Turning to the more indirect and complex sensory measures (Naming Pictures of Objects, Palm Writing, and Object Identification), it became apparent that each test contains one or more items which are considerably more difficult than the majority. On Naming Pictures of Objects, participants had seven times more difficulty identifying the cross correctly than any other item. Feedback requested from participants suggested that either a slight change in the scoring criteria or in the drawing would raise the *p* value to make it more consistent with the other items.

In spite of the fact that coins have traditionally been used to test stereognosis, over 15% of the participants in this study responded incorrectly when asked to identify a dime and a nickel by touch alone. However, the object found to be most difficult for participants to identify was the candle. Alternates which might be considered for increasing the *p* values of these stereognosis items include the use of a coin for one hand and a button for the other (with no requirement to name the denomination of the coin), and replacement of the candle with a more widely-handled object such as a die.

On Palm Writing, none of the participants missed any of the letter stimuli (x or o). The majority of the errors were made for numbers 1 and 3. The large intermanual discrepancy (47 right, 26 left) in errors found on this test may reflect the fact that the symbols were administered first to the dominant hand of most individuals thus providing an opportunity for interhemispheric transfer of language-mediated information.

Motor Assessment. Raters tend to have greater difficulty discriminating between the absence and presence of mild symptoms which, in clinical practice, is much more serious than confusion between levels of presence (Cicchetti et al., 1992). The opportunity to assess agreement in discrimination of absence-presence, however, is relatively rare in clinical samples. This study was unusual in that it provided an opportunity to estimate rater agreement for that discrimination. In spite of sample homogeneity (here associated with low base rates) and differential weighting for calculation of chance-corrected agreement, each of which results in a more stringent estimate than is otherwise the case (Cicchetti, 1976; Shrout, Spitzer, & Fleiss, 1987), the majority of weighted kappa (*kappa w*) values were good or excellent.

For Gait and Station, 7 of 10 total disagreements for the heel-to-toe item and 6 of the total disagreements for the hopping item were for the absence-presence discrimination. Absence-presence discrimination on the Romberg item heel-to-toe constituted 31 of 33 total disagreements. The difference in discrimination by raters on this item was further investigated by calculating chance corrected agreement for specific weighted categories (*kappa s*). This investigation showed good agreement for both the *absence* and *mild* categories. For the finger-to-nose test, 12 of 15 and 8 of 12 total disagreements for the right and left hands respectively were for absence-presence discrimination.

Although *kappa w* values were good, the presence of any confusion by trained raters suggests that videotaped training materials might help clarify the written criteria and enhance both agreement and accuracy. Additionally, it will be important to provide a practice trial for many of the motor items to minimize the anxiety associated with having examinees close their eyes. Although an age effect may have been suspected for these tasks, consideration of the data did not support that argument.

Woodward et al. (in preparation) concluded that although sensory and motor functions are routinely assessed within a variety of clinical and research settings (Horton & Puente, 1986; Richards et al., 1993), application of traditional procedures of test development has been largely neglected (Buchanan & Heinrichs, 1989). The D-WSMB improves upon other sensory and motor batteries by offering standard procedures for administration and scoring as well as guidelines for discriminating severity of symptoms. However, the necessity of relying on rater judgement for some tests remains. In those cases where subjective discriminations are required, this study showed that rater agreement and rater reliability are of paramount importance. In concert with Franzen's (1989) argument that reliability can better be understood using multiple strategies of estimation and Cicchetti's (1988) argument that the data should be examined at finer levels, the Woodward et al. study utilized analyses which allowed ready comparison across several levels. In sum, results of this study suggest adequate to excellent rater agreement and reliability (i.e., generalizability) for the tests included in the D-WSMB. In view of the effect of sample homogeneity, the difficulty generally noted in discriminating motor behavior (Albert, 1988), and the use of stringent analyses, this outcome is especially impressive. The present results also suggests that with few modifications reduction of variance related to items and person-item interactions may be expected to decline, effectively reducing the likelihood of false-positive decisions.

Developmental Differences. Despite evidence that age-related differences exist, the interpretation of tests of sensory and motor functions are commonly based on the assumption that these functions can be assessed and interpreted in the same manner across the life span (Peters, Romine, & Dykman, 1975; Rasmussen, Gillberg, Waldenstrom, & Svenson, 1983). This approach is based on the idea that poor performance on sensory-motor measures is a pathognomonic indicator regardless of age. Moreover, there is the belief that these sensory and motor differences are similar for both children and adults. This assumption may be perpetuated by the lack of data considering sensory and motor functioning across the life span. However, recent research has demonstrated developmental differences for standardized sensory-motor functions (Arceneaux, Hill, Chamberlain, & Dean, 1997; Huttenlocher, Levine, Huttenlocher, & Gater, 1990).

Until recently, there has been a lack of data considering sensory and motor functioning during preschool and elementary school years. For example, Huttenlocher et al. (1990) studied normal and at-risk preschool aged children for learning difficulties by using a neurological screening test which included simple sensory-motor tasks. The results showed that such tests allowed the identification of children who may be in need of special education and more extensive neuropsychological testing. The authors concluded that this would be beneficial in assisting educators so that early education programs could be initiated. Similarly, Huttenlocher et al. (1990) called for more research documenting the development of sensory and motor functions in early childhood.

The timing and manner in which sensory-motor deficits manifest themselves appear to be related to specific damage and the rate of brain maturation. Sensory-motor development is thought to be dependent upon dendritic arborization (Kolb & Whishaw, 1996). Subsequent to neuronal migration, further dendritic development is necessary for the integration of sensory and motor functioning. In addition, many fibrous tracts of the central nervous system are not fully myelinated until the first few years of life (Hynd & Willis, 1988). This myelination is characterized by the maturation of terminal zones, and subcortical and primary cortical regions (Luria, 1966). This maturation is thought to result in simple fine-grained movement and increased perceptual acuity and to provide a foundation for the emergence of increasingly complex sensory-perceptual abilities, motor control, and language skills (Hynd & Willis, 1988). Given the nature of cortical maturation, it is not surprising that early observation of sensory and motor abnormalities predict future possible cognitive deficits.

Children's sensory and motor functions greatly increase in the age range of five to seven years. This time in development is said to be a critical period caused by a neurological shift (Piaget, 1952) related primarily to brain development in the tertiary regions and terminal zones of the brain (Geschwind, 1975).

There is disagreement as to whether differences in sensory and motor functions are linked to gender (Lloyd & Archer, 1976; Fairweather, 1976). Indeed, no consistent or interpretable pattern of differentiation between genders has been identified (Dodrill, 1979). For example, some authors report that females demonstrate more advanced motor coordination than males, but that males develop earlier sensory discrimination skills. Piaget (1952) reported that sex hormones may have structural and functioning effects on the developing organism.

A recent study by Lang, Hill, and Dean (in preparation) examined cross-sectional developmental differences for the D-WSMB. The participants consisted of 288 children (138 males and 150 females) ranging in age from 48 to 191 months (4 years through 15 years, 11 months). The mean age for males was 104.5 months with a standard deviation of 30.4 and for females it was 101.1 months with a standard deviation of 31.4. All subjects had a negative history of any neurological or psychiatric disorder. The means for each of the tests were computed for each of the 10 age groups and are presented in Table 2-5. Note the participants in the 2- and 3-year-old age range were combined due the similar levels of performance. Participants between the ages of 12 and 15 were combined for the same reasons. The italicized means of each measure indicate the level at which performance failed to increase incrementally with age. The means in bold type were consistent with adult performance on these tasks (Woodward, Ridenour, & Dean, in preparation). A series of comparisons were computed to examine meaningful changes in performance. The last italicized mean for each test was compared to the first bolded mean. In each case the difference was statistically significant ($p < .01$). In addition, to demonstrate that bolded means were meaningfully different, the italicized means were collapsed and compared to the first mean outside the box. Again, these differences were statistically significant ($p < .01$) for each variable.

This study showed that most of the sensory and motor tests used by neurologists and neuropsychologists have a developmental underpinning. In the past, it was assumed that the development of sensory-motor functions were the same in adults as they were in children. However, this study showed that developmental differences are within documented age ranges. Often interpretation relies upon left-versus-right differences. Moreover, it has long been a practice of neurologists and neuropsychologists to use pathognomonic indicators as a sign of neuropathology and thus bypass standardized administration and scoring procedures. This study suggests that this practice can lead to false positives. It can no longer be presumed that developmental indicators that predict abnormalities in adults also predict abnormalities in children.

Factor Analysis. In a recent study by Hill, Lewis, Dean, & Woodcock (in press), the underlying constructs of D-WSMB were investigated. The factor

Table 2-5.
Mean Values for Each Variable at Each Age

Variable	Age									
	2–3	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12–15**
Visual Perception										
Simple										
Dominant	10.2	19.46	**21.12**	**23.13**	**23.52**	**22.40**	**23.25**	**23.19**	**23.20**	**23.87**
Non-Dominant	9.6	18.79	**21.16**	**23.05**	**23.21**	**22.93**	**23.07**	**22.69**	**22.92**	**23.74**
Bilateral	3.6	8.96	**10.12**	**11.21**	**11.31**	**11.33**	**11.00**	**11.01**	**11.32**	**11.81**
Naming Pictures of Objects	*2.3*	*3.17*	*3.88*	**4.46**	**4.55**	**4.63**	**4.61**	**4.64**	**4.8**	**4.87**
Auditory Perception										
Simple										
Dominant	*3.8*	*6.63*	**7.48**	**7.67**	**7.76**	**7.57**	**7.50**	**7.67**	**7.72**	**7.94**
Non-Dominant	*3.7*	*6.75*	**7.68**	**7.28**	**7.43**	**7.73**	**7.64**	**7.50**	**7.80**	**7.94**
Bilateral	*1.5*	*3.04*	**3.52**	**3.49**	**3.60**	**3.63**	**3.64**	**3.58**	**3.80**	**3.97**
Palm Writing										
Letters										
Dominant	*3.5*	*7.04*	**8.60**	**8.44**	**8.91**	**8.88**	**8.96**	**8.94**	**9.00**	**9.00**
Non-Dominant	*3.3*	*7.13*	**8.52**	**8.41**	**8.86**	**8.75**	**9.00**	**8.92**	**8.96**	**9.00**
Numbers										
Dominant	*.4*	*2.45*	*4.40*	*4.92*	*5.77*	*5.47*	**7.25**	**7.25**	**7.32**	**8.10**
Non-Dominant	*.4*	*1.82*	*3.32*	*5.00*	*5.75*	*6.00*	**7.50**	**7.75**	**7.92**	**8.10**
Object Identification										
Dominant	*1.6*	*3.13*	*4.44*	*4.41*	*4.77*	*4.84*	***5.29***	***5.33***	**5.56**	**5.74**
Non-Dominant	*1.2*	*2.58*	*3.92*	*4.26*	*4.5*	*4.78*	*4.93*	**5.08**	**5.36**	**5.32**
Finger Identification										
Dominant	*1.1*	*8.17*	*8.28*	**9.44**	**9.39**	**9.69**	**9.96**	**9.83**	**9.92**	**9.77**
Non-Dominant	*1.1*	*7.88*	*8.04*	**8.95**	**9.30**	**9.69**	**9.89**	**9.81**	**9.84**	**9.61**
Tactile Perception										
Simple										
Dominant	*4.7*	**7.21**	**7.92**	**7.97**	**7.84**	**7.87**	**7.82**	**7.97**	**8.00**	**7.94**
Non-Dominant	*4.2*	**7.29**	**7.68**	**7.82**	**7.84**	**7.78**	**7.86**	**7.92**	**8.00**	**7.97**
Bilateral										
Both Hands	*1.6*	***3.29***	**3.92**	**3.87**	**3.79**	**3.78**	**3.89**	**3.94**	**4.00**	**4.00**
Hand/Cheek—Right	*.3*	*.67*	**.96**	**.82**	**.86**	**.91**	**.93**	**.97**	**1.00**	**1.00**
Hand/Cheek—Left	*.1*	*.63*	**.96**	**.82**	**.86**	**.91**	**.96**	**.97**	**1.00**	**.97**
Left Hand/Right Cheek	*.1*	*1.67*	**2.56**	**2.51**	**2.65**	**2.66**	**2.75**	**2.83**	**2.96**	**2.77**
Right Hand/Left Cheek	*.3*	*1.75*	**2.56**	**2.49**	**2.53**	**2.69**	**2.86**	**2.83**	**3.00**	**2.90**
Gait and Station										
Free Walking	**4.0**	**3.92**	**3.96**	**4.00**	**4.00**	**3.91**	**3.93**	**4.00**	**4.00**	**3.97**
Heel-to-Toe Walking	*1.3*	*3.12*	**3.60**	**3.51**	**3.61**	**3.72**	**3.68**	**3.92**	**3.92**	**3.94**
Hopping	*1.3*	*3.17*	**3.80**	**3.72**	**3.77**	**3.91**	**3.86**	**3.92**	**4.00**	**3.94**
Station	*3.5*	**3.88**	**4.00**	**3.95**	**3.98**	**3.91**	**3.93**	**4.00**	**4.00**	**3.97**
Romberg										
Feet Together	***3.9***	**3.75**	**3.92**	**3.9**	**3.91**	**3.88**	**3.96**	**3.94**	**4.00**	**3.94**
Heel-to-Toe	1.3	*2.92*	*3.04*	**3.26**	**3.11**	**3.41**	**3.07**	**3.53**	**3.48**	**3.39**
One Foot	1.0	*2.63*	**2.76**	**2.77**	**2.80**	**3.13**	**2.89**	**3.11**	**3.60**	**3.13**
Construction										
Cross	*.4*	*2.29*	*5.40*	*6.55*	*6.64*	*7.47*	*8.07*	**8.64**	**8.92**	**8.67**
Clock	*.4*	*2.00*	*6.12*	*6.42*	*9.05*	*10.75*	**12.00**	**11.92**	**12.04**	**12.03**
Coordination: Finger-to-Nose										
Dominant	*1.8*	*3.35*	*3.64*	**3.74**	**3.82**	**3.94**	**3.82**	**3.86**	**3.96**	**3.94**
Non-Dominant	*1.7*	*3.43*	*3.64*	**3.74**	**3.80**	**3.88**	**3.82**	**3.83**	**4.00**	**4.00**

Table 2-5 (cont.)

Rapidly Alternating Movements:										
Hand/Thigh—Dominant	—	*25.23*	*19.85*	*17.98*	*16.16*	*16.98*	*15.77*	**15.01**	**13.72**	**13.07**
Hand/Thigh—Non-Dominant	—	*26.80*	*21.52*	*19.92*	*17.42*	*18.41*	*16.36*	**15.63**	**14.22**	**13.10**
Mime Movements	*1.6*	*3.08*	*3.8*	**4.18**	**4.11**	**4.47**	**4.61**	**4.36**	**4.56**	**4.68**
Left/Right Movements	*1.3*	*3.91*	**5.48**	**5.49**	**5.55**	**5.59**	**5.82**	**6.00**	**5.88**	**5.97**
Finger Tapping:										
Dominant	12.79	24.46	30.73	34.00	34.47	35.47	38.40	41.14	39.75	41.66
Non-Dominant	12.02	23.25	25.75	30.42	31.37	31.50	34.64	37.63	36.47	37.72
Expressive Speech	24.40	17.17	15.36	13.64	13.16	12.31	**11.82**	**11.08**	**10.56**	**10.71**

Note: Numbers in italics indicate the level at which performance failed to increase incrementally with age. Means in bold are consistent with adult performance on these factors.

structure of this wide-band measure of sensory-motor functioning was assessed using exploratory procedures. Two competing hypotheses were developed for the factor analysis. First, it was hypothesized that two constructs underlie the D-WSMB such that analysis would reveal a two-factor solution. In this case, one factor would represent sensory functions and the other factor would represent motor functions. Our second hypothesis was based on the notion that a three-factor solution would result with the factors representing the constructs of sensory functions, cortical motor functions, and subcortical motor functions. Regardless of the number of factors that emerged, we hypothesized that the resulting factors would be highly correlated and require an oblique rotation.

Participants were 617 volunteers who ranged in age from 2 to 88 years of age (M = 17.95, SD = 15.78). Demographic data for the participants are presented in Table 2-6. Some (119) of the participants had neurologic or psychiatric diagnoses.

An exploratory factor analysis using a principle components extraction procedure was used to investigate the underlying structure of the D-WSMB. An exploratory rather than a confirmatory factor analysis was chosen for this study because although the underlying structure of the D-WSMB had been hypothesized, it had not yet been examined statistically.

An examination of the “scree plot” and proportion of variance explained suggested a three-factor solution (see Table 2-7). A comparison of chi-square values for the two- and three-factor models indicated a significant difference between the solutions (change in χ^2 = 6062.86, change in df = 36, p < .0001), thus a three-factor model was retained. Moreover, examination of the loadings for the two- and three-factor solutions confirmed a three-factor solution (empirically and theoretically) which accounted for 50.9% of the total variance. Initial rotation was done using the varimax technique. However, as hypothesized, direct oblimin rotation revealed interpretable correlations between factors. Table 2-8 presents the structure matrix for the three-factor solution with direct oblimin rotation. The criterion of an absolute value of .35 or greater was used to judge the significance of the loadings (Pedhazur & Schmelkin, 1991).

The majority of items primarily loading on Factor 2 demonstrated dual loadings with Factor 1. Strength of grip loaded highest on Factor 2, which appears most sensitive to motor functions.

Table 2-6.
Breakdown of Demographic Variables by Number and Percentage of Participants

Variable	***n***	**Percentage of *N***
Age		
2–4 Years	35	5.7
5–8 Years	161	26.1
9–14 Years	185	30.0
15–54 Years	210	34.0
54+ Years	26	4.2
Gender		
Male	271	43.9
Female	346	56.1
Race		
White	566	91.7
African American	21	3.4
Asian	8	1.3
Native American	2	.3
Other	16	2.6
Not Reported	4	.6
Education		
0–8 years	381	61.8
9–12 years	63	10.2
13–16 years	99	16.0
17+ years	71	11.5
Not reported	3	.5
Psychiatric/Neurologic History		
None	498	80.7
Psychiatric	33	5.3
ADHD	29	4.7
Neurological	31	5.0
Developmental/Educational	21	3.4
Medical	5	.8

Indeed, items with high loading on Factor 2 reflect higher cortical motor functions that integrate complex sensory skills. Thus, Factor 2 was seen as representative of Motor and Complex Sensory Skills.

Those variables which met criteria for loading significantly on Factor

Table 2-7.
Three Factors of the the Sensory Motor Battery

Sensory and Simple Motor Skills	**Motor and Complex Sensory Skills**	**Subcortical Motor Impairment**
1. Visual Perception	1. Grip Strength	1. Romberg
2. Bilateral Visual Perception	2. Palm-Writing: Numbers	2. Gait and Station
3. Tactile Perception	3. Clock Construction	3. Near Point Visual Acuity
4. Palm-Writing: Letters	4. Finger-Tapping	
5. Finger Identification	5. Cross Construction	
6. Finger to Nose	6. Object Identification: Tactile	
7. Mime Movements	7. Hand-Thigh	
8. Right-Left Movements	8. Expressive Speech	
9. Auditory Perception		

Table 2-8.
Oblimin Structure Matrix for a Three-Factor Solution

Variable	**Factor 1**	**Factor 2**	**Factor 3**
Simple Visual Perception—Dominant	.78	—	—
Simple Visual Perception—Non-Dominant	.81	—	—
Bilateral Visual Perception	.75	—	—
Simple Tactile Perception—Dominant	.83	—	—
Simple Tactile Perception—Non-Dominant	.83	—	—
Bilateral Tactile Perception—Both Hands	.77	—	—
Bilateral Tactile Perception—Contralateral	.66	–.50	—
Palm Writing: Letters—Dominant	.75	–.39	—
Palm Writing: Letters—Non-Dominant	.82	–.37	—
Finger Identification—Dominant	.70	–.48	—
Finger Identification—Non-Dominant	.72	–.48	—
Coordination: Finger-to-Nose—Dominant	.62	—	–.44
Coordination: Finger-to-Nose—Non-Dominant	.64	—	–.41
Bilateral Tactile Perception—Ipsilateral	.54	—	–.37
Simple Auditory Perception—Non-Dominant	.60	—	–.37
Bilateral Auditory Perception	.55	—	—
Left-Right Movements—Dominant	.53	–.47	—
Left-Right Movements—Non-Dominant	.55	–.53	—
Mime Movements	.50	–.48	—
Strength of Grip—Dominant	—	–.80	—
Strength of Grip—Non-Dominant	—	–.78	—
Palm Writing: Numbers—Dominant	.45	–.76	—
Palm Writing: Numbers—Non-Dominant	.48	–.78	—
Clock Construction	.48	–.78	—
Finger-Tapping—Dominant	.46	–.72	—
Finger-Tapping—Non-Dominant	.44	–.76	—
Cross Construction	.52	–.69	—
Naming Pictures of Objects	.52	–.62	—
Object Identification—Dominant	.46	–.64	—
Object Identification—Non-Dominant	.49	–.61	—
Coordination: Hand-Thigh—Dominant	—	.65	—
Coordination: Hand-Thigh—Non-Dominant	—	.61	—
Age in Months	—	–.57	.42
Expressive Speech	–.46	.57	—
Romberg: Feet Together		—	–.72
Romberg: Heel to Toe	.38	—	–.68
Romberg: One Foot	.37	—	–.64
Gait and Station: Free Walking	—	—	–.74
Gait and Station: Heel to Toe	.59	—	–.69
Gait and Station: Hopping	.56	—	–.72
Gait and Station: Station	.42	—	–.68
Near Point Visual Acuity—Dominant	—	—	.37
Near Point Visual Acuity—Non-Dominant	—	—	.32
Simple Auditory Perception—Dominant	.31	—	—

3 represented motor skills which have historically been considered primarily subcortical in origin. These were characterized by tests of Gait and Station and Romberg item heel-to-toe. Although measures of finger-to-nose coordination did not load primarily on this factor, their secondary loadings provide support for the notion that this factor represents subcortical motor elements. This suggested that Factor 3 should be considered Subcortical Motor skills.

The present data suggested that although the D-WSMB factors are not pure measures of sensory-perception, cortical motor, and subcortical motor functions, they offer a means to conceptualize a broad range of sensory and motor skills during the neurologic/neuropsychological examination. This study provided empirical support for the underlying constructs of the D-WSMB and its utility as a measure of multiple dimensions of sensory and motor functioning.

Dean-Woodcock Structured Interview and Mental Status Exam

The luxury of the control for facilitators and inhibitors of cognitive and sensory-motor functioning used in laboratory research is not possible in the clinical setting. Therefore, the interpretation of the data resulting from the neuropsychological examination must attempt to account for factors such as emotional state, motivation, temperament, and prior medical conditions which may influence performance. For example, attributing impaired cognitive functioning to brain injury in a patient with a long-standing psychiatric disorder is questionable. Similarly, while scores on measures of written language may well be similar to those for patients with known neurological conditions, facilitators and inhibitors must be ruled out prior to the diagnosis of neurologically related conditions. In addition, a patient's premorbid history, age at onset, and emotional reaction to an impairment all may interact to obscure diagnostic findings (Dean, 1989).

As is true in other health sciences, a patient's presenting symptoms must be interpreted relative to his or her medical, social, and family history. Although it is often difficult to examine the effect of education, social-economic status, and occupation, each has been shown to be related to the performance on psychological measures in general and on measures of neuropsychological measures specifically. Early on, Parsons and Prigatano (1978) reported a considerable relationship between the results on measures of neuropsychological functioning and the level of education for general medical patients. However, the relationship between these variables for neurological and psychiatric patients was not as clear. Dean (1989) argued that the adult patient's premorbid occupation and the concomitant opportunity to refine academic skills may offer a more potent predictor of neuropsychological functioning. Indeed, there seems to be a substantial relationship between social-economic status when measured by occupation and normal individuals' general cognitive ability (Wilson et al., 1978). The effect of race on neuropsychological functioning is not as clear. Although some have hypothesized a genetic component for race on such measures (Dean, 1989), the interaction of social-economic differences and aspects of cultural transmission make interpretation of these data for the individual patient a tenuous procedure. While statistical methods of predicting expected premorbid levels of neuropsychological functioning are used and normative data exist for demographic variables, such variables may have varying degrees of influence on the performance for individual patients.

As one would expect, the effect of age on neuropsychological performance is clearest at the two extremes. In this regard, the D-WNAS offers age-appropriate norms useful in assessing the neuropsychological functions of children and adults. Normative controls for age are readily available with the WJ-R. Although diminution in some neuropsychological functions is known to exist with advancing years, the extent to which these results are dependent on past learning and experience is not clear.

Within the area of premorbid history, the patient's developmental and medical history provides insight into his or her neuropsychological performance. Thus, the patient's functioning level must be evaluated in light of seemingly unrelated factors. While a head injury with loss of consciousness at age 12 may appear of little interest in the 40-year-old patient with memory loss, the interpretation of inconsistencies in the patient's neuropsychological examination may be attributed in part to such an early closed-head injury. Without knowledge of the patient's premorbid history, differential diagnosis becomes less reliable. This does not mean to imply that memory problems at the age of 40 are directly attributed to early closed-head injury, but rather to suggest closed-head injuries may have neuropsychological effects years later. These effects may confuse a current diagnostic picture.

The *Structured Interview* portion of the D-WNAS offers a systematic approach to the collection of information concerning the patient's present state and history, which have shown to be useful in the interpretation of the results of any psychological testing, and more important, in making neuropsychological conclusions (Dean, 1993). The Structured Interview is such that all the relevant factors in the patient's background may be taken into account. Spanish-language questions exist for the entire measure.

The *Mental Status Exam* of the D-WNAS allows the systematic collection of emotional/psychiatric data useful in understanding the patient. The neuropsychological examination involves the cooperation and concentration of the patient. Therefore, it is not unreasonable to consider a patient's level of emotional functioning as a potential moderating variable of neuropsychological functioning. For example, a number of studies have shown that when chronic schizophrenics are excluded from consideration, the accuracy rate of the neuropsychological examination in differentiating psychiatric patients is not significantly different than that found between normals and brain damaged. Although this conclusion seems robust, emotional disturbance exists in both psychiatric and neurological patients; therefore, the question arises as to the effects of emotional disturbance on neuropsychological findings.

Perhaps a most frequent referral question asked of the neuropsychologist in the psychiatric setting involves the differential diagnosis of "organic" and "functional" mental disorders. Of course, the distinction between organic and functional disorders is presently not as clear as it once was assumed. While this distinction might seem better understood as a continuum than a nosological dichotomy, these terms hold a good deal of tradition in psychiatric literature. At the same time, an increasing database has accumulated which questions the biochemical and structural anomalies for numerous psychiatric disorders hitherto described as having a functional locus (e.g., Rockford, Detre, Tucker, & Harrow, 1970).

A related issue is the use of the term “organicity” as though it were a unitary phenomena. The tradition for its usage relates to theories which held that the behavioral effects of brain damage were similar without regard to location (Goldstein, 1942). Variations in the behavioral manifestations of brain damage were seen to be more an interaction of the severity of cortical involvement and the patient’s premorbid personality than a result of the specific location of the lesion. From this point of view, a classic syndrome of behavioral and psychogenic signs were sought as characteristic of “organicity.” This conclusion has been successfully challenged as too simplistic. Indeed, research has shown distinctly different behavioral consequences could be attributed to focal lesions which differ in location (Reitan, 1955). In fact, evidence indicates that the patient’s age, the acuteness of the lesion, and the length of the interval between brain damage and assessment are of such importance as to invalidate the usefulness of “organicity" as a unitary phenomenon (Reitan & Davidson, 1974).

Clearly, affective and psychiatric components may be the result or cause of neurological/neuropsychological functioning (Dean, 1986). Indeed, “functional” psychiatric features (e.g., depression) may have in the past been the result of emotional-environmental factors (Dean, 1987). It has become clear that psychiatric features and diagnosis lie on a continuum from “pure functional” (e.g., Post Traumatic Stress Disorder) to “primarily organic” (e.g., Frontal Lobe Syndrome) with the majority of psychiatric disorders occurring somewhere on this continuum (Dean 1986).

Neuropsychological assessment has made its most significant contribution in psychiatric settings where equivocal evidence existed concerning the patient’s neurological integrity. Neuropsychological assessment examines a comprehensive array of behaviors that are compared to normative standards and those occurring in known, neurological conditions. Such information allows the examination of “minor” behavioral/cognitive impairment which is often the early sign of neurologically related disorders. Of use in differential diagnosis, these data also provide the clinician information concerning the extent of a patient’s behavioral impairment relative to normal cohorts and known pathological groups. For example, in evaluating psychiatric aspects of a closed-head injury, neuropsychological assessment provides information useful both in diagnosis and in understanding the severity of impairment in cognitive, sensory-motor, and emotional functioning. The extent to which the patient displays residual impairment relative to his or her premorbid state offers useful information in rehabilitation planning. Thus, an assessment of a patient’s mental status at the time of the neuropsychological examination becomes crucial in our understanding of a patient’s cognitive and sensory-motor functioning.

Section III: Recent Research Using the WJ-R

Clinical Sample

In a continuing effort to investigate the validity of the WJ-R and Batería-R in clinical neuropsychology, a data pool of neurological and psychiatric patients continues to be collected. This report documents results from a sample of 1,315 patients, age 5 to 81 years, who have scores available for WJ-R COG tests 1 to 14. Patients were diagnosed independent of the results of the WJ-R by a neurologist, neurosurgeon, psychiatrist, or psychologist, depending upon the disorder. Some patients have dual diagnoses and may appear in more than one clinical group. Therefore, a patient with a seizure disorder may also be classified as having a head injury. In each case, the patients met diagnostic criteria offered by the *Diagnostic and Statistical Manual for Mental Disorders* (DSM-IV) (American Psychiatric Association, 1994) or ICD-9. Diagnoses requiring lesion localization (e.g., tumors, traumatic lesion) were identified with either an MRI or CT-scan of the brain.

Validity Studies

Our research has just begun to examine the utility of the *Dean-Woodcock Neuropsychological Assessment System* (D-WNAS) (Dean & Woodcock, in preparation) with the above clinical sample, and a number of overviews will be reported here. These analyses include (a) a factor analysis of 19 cognitive and achievement tests of the WJ-R for 1,032 members of the full clinical sample, (b) descriptive data including the median standard scores and standard deviations by clinical diagnoses for the 7 *Gf-Gc* factors and for the 14 WJ-R COG tests, and (c) the results of five discriminant analyses between groups. In an effort to outline the clinical utility of the D-WNAS, this research report will conclude with an examination of a number of clinical cases.

Factor Structure

The factor structure for 14 of the WJ-R COG tests and 5 of the WJ-R ACH tests was analyzed for the pool of clinical subjects. Data on these 19 variables were available for 1,032 subjects. The age of the subjects ranged from 5 to 81 years and standard scores were based on age. (Table 3-3, to be described later, indicates the variety of neurologic and psychiatric diagnoses represented in the group.)

The scores for the 1,032 subjects were submitted to a factor analysis using the iterated principal axis (IPA) procedure followed by an equamax rotation. A nine-factor solution was specified to parallel the number of *Gf-Gc* factors described earlier in this report. The results of the factor analysis on the clinical group data are presented in Table 3-1.

An inspection of Table 3-1 indicates that the factor structure observed in this set of clinical data approximates the structure predicted by *Gf-Gc* theory. As a comparison, Table 3-2 presents results from the same analysis procedure on 5,470 subjects in the WJ-R norming sample. The factor structure observed in Table 3-1 for the clinical sample approximates that reported for the standardization sample in Table 3-2. Similar exploratory

Table 3-1.
Nine-Factor Equamax Rotation of the Clinical Sample (*N* = 1,032, Age = 5 to 81 Years)

	Factor Loadings									
Test	***Gc***	***Grw***	***Gq***	***Gv***	***Ga***	***Glr***	***Gf***	***Gsm***	***Gs***	h^2
Acquired Knowledge:										
Picture Vocabulary	.66	—	—	—	—	—	—	—	—	.49
Oral Vocabulary	.52	.32	—	—	—	—	.32	.30	—	.39
Letter-Word Identification	—	.68	—	—	—	—	—	—	—	.86
Passage Comprehension	.34	.58	.30	—	—	—	—	—	—	.83
Dictation	—	.53	.35	—	.35	.33	—	—	—	.78
Calculation	—	.33	.56	—	—	—	.36	—	.30	.75
Applied Problems	—	—	.70	—	—	—	—	—	—	.90
Thinking Ability:										
Visual Closure	—	—	—	.47	—	—	—	—	—	.39
Picture Recognition	—	—	—	.54	—	—	—	—	—	.49
Incomplete Words	—	—	—	—	.42	—	—	—	—	.32
Sound Blending	—	—	—	—	.63	—	—	—	—	.65
Memory for Names	—	—	—	—	—	.67	—	—	—	.57
Visual-Auditory Learning	—	—	—	.30	—	.52	.38	—	—	.70
Analysis-Synthesis	—	—	.33	—	—	—	.55	—	—	.65
Concept Formation	—	—	—	—	—	—	.58	—	—	.70
Cognitive Efficiency:										
Memory for Sentences	.30	—	—	—	—	—	—	.71	—	.78
Memory for Words	—	—	—	—	.30	—	—	.65	—	.67
Visual Matching	—	—	—	—	—	—	—	—	.78	.80
Cross Out	—	—	—	.32	—	—	—	—	.67	.71

Note: Loadings < .30 not reported.

and confirmatory factor analysis results on various groups in other settings may be found in McGrew, Werder, and Woodcock (1991) and Woodcock (1990).

The results of these factor analyses support the construct validity of the WJ-R with neurological and psychiatric patients commonly seen in neuropsychological practice. The results also provide evidence of validity for using the *Gf-Gc* model and WJ-R clusters in drawing neuropsychological conclusions.

Descriptive Statistics for Clinical Groups

Table 3-3 presents descriptive statistics for Broad Cognitive Ability and the seven *Gf-Gc* clusters for several clinical groups. In each case, the subject's cluster score was transformed to an age-based standard score scale with a mean of 100 and a standard deviation of 15. In addition, the median (*Mdn*), which is less influenced by extreme scores, is reported. The extent to which scores were dispersed can be appreciated with the standard deviation (*SD*). Although the number of subjects in some clinical groups was rather low,

Table 3-2.
Nine-Factor Equamax Rotation of the WJ-R Norming Sample (*N* = 5,470)

	Factor Loadings									
Test	***Gc***	***Grw***	***Gq***	***Gv***	***Ga***	***Glr***	***Gf***	***Gsm***	***Gs***	***h²***
Acquired Knowledge:										
Picture Vocabulary	.71	—	—	—	—	—	—	—	—	.78
Oral Vocabulary	.55	.34	.28	—	—	—	—	.27	—	.75
Letter-Word Identification	.25	.65	—	—	.25	—	—	—	—	.72
Passage Comprehension	.36	.42	.29	—	—	—	—	—	—	.63
Dictation	—	.60	.31	—	—	—	—	—	—	.69
Calculation	—	.28	.68	—	—	—	—	—	—	.72
Applied Problems	.28	—	.62	—	—	—	.29	—	—	.72
Thinking Ability:										
Visual Closure	—	—	—	.38	—	—	—	—	—	.29
Picture Recognition	—	—	—	.59	—	—	—	—	—	.48
Incomplete Words	—	—	—	—	.51	—	—	—	—	.41
Sound Blending	—	—	—	—	.58	—	—	—	—	.53
Memory for Names	—	—	—	—	—	.67	—	—	—	.61
Visual-Auditory Learning	—	—	—	.27	—	.56	.29	—	—	.60
Analysis-Synthesis	—	—	.29	—	—	—	.51	—	—	.52
Concept Formation	—	—	—	—	—	—	.63	—	—	.63
Cognitive Efficiency:										
Memory for Sentences	.25	—	—	—	—	—	—	.72	—	.45
Memory for Words	—	—	—	—	—	—	—	.58	—	.72
Visual Matching	—	—	—	—	—	—	—	—	.83	.81
Cross Out	—	—	—	—	—	—	—	—	.62	.57

Note: Loadings < .25 not reported.

many groups were of a size in which rather robust insights were possible. It is important to note that further data collection and analyses are in progress and will be reported in professional journals and future research reports.

For purposes of comparison of the *Gf-Gc* clusters, Table 3-3 also includes summary data for the 5,470 subjects of the WJ-R norming sample (see the *WJ-R Examiner's Manuals* for a full description). A sample of 84 identified gifted subjects is also included for an additional comparison. It will be seen that the medians and standard deviations reported for the clinical subgroups differ markedly from the WJ-R norming sample baseline. Excluding the category of Deficits in Acquired Knowledge, a review of Table 3-3 indicates that median cognitive cluster scores range from 62 on *Gc* in the mentally retarded group to 102 on *Gc* in the motor impairment group. Reviewing the medians across clinical groups draws attention to a common pattern of deficits related to processing speed (*Gs*), verbal comprehension-knowledge (*Gc*), and long-term storage-retrieval (*Glr*). On the other hand, visual processing (*Gv*) scores appear to "hold" in almost every clinical group. Other abilities that are often not seriously impaired include short-

Table 3-3.
Gf-Gc Cluster Score Pattern by Type of Sample (Age = 5 to 81 Years)

			***Gf–Gc* Cluster by Standard Score Order**						
Sample	***n***	**BCA**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Reference Samples:									
WJ-R Norming Sample	5,470	Cluster: BCA	*Gv*	*Gc*	*Gf*	*Ga*	*Gs*	*Glr*	*Gsm*
		Mdn: 100	100	100	100	100	100	100	100
		SD: 16	16	16	15	15	16	16	16
Total Clinical Sample	1,315	Cluster: BCA	*Gs*	*Glr*	*Gc*	*Ga*	*Gf*	*Gsm*	*Gv*
		Mdn: 90	87	91	92	93	93	94	98
		SD: 18	18	15	18	15	17	18	17
Gifted	84	Cluster: BCA	*Gv*	*Gsm*	*Ga*	*Glr*	*Gf*	*Gs*	*Gc*
		Mdn: 120	105	110	111	112	116	118	120
		SD: 11	13	15	13	16	11	14	13
Clinical Samples:									
Deficits in Acquired Knowledge									
Knowledge < 70	56	Cluster: BCA	*Gc*	*Gf*	*Gs*	*Gsm*	*Glr*	*Ga*	*Gv*
		Mdn: 56	58	65	68	70	72	73	7
		SD: 11	10	12	15	12	16	11	1
Math < 70	122	Cluster: BCA	*Gs*	*Gc*	*Gf*	*Gsm*	*Glr*	*Ga*	*Gv*
		Mdn: 64	68	68	72	77	78	80	82
		SD: 14	15	16	12	14	15	13	16
Oral Language < 70	63	Cluster: BCA	*Gc*	*Gsm*	*Gf*	*Gs*	*Glr*	*Ga*	*Gv*
		Mdn: 59	60	70	70	71	73	74	77
		SD: 10	10	11	11	12	12	11	15
Reading < 70	133	Cluster: BCA	*Gc*	*Gs*	*Gsm*	*Gf*	*Glr*	*Ga*	*Gv*
		Mdn: 66	69	72	75	76	77	82	89
		SD: 15	16	13	15	14	13	13	16
Written language < 70	164	Cluster: BCA	*Gs*	*Gc*	*Glr*	*Gsm*	*Gf*	*Ga*	*Gv*
		Mdn: 70	75	76	78	78	80	83	89
		SD: 15	14	16	12	15	14	13	16
Anxiety Spectrum Disorders	100	Cluster: BCA	*Gs*	*Glr*	*Ga*	*Gc*	*Gf*	*Gsm*	*Gv*
		Mdn: 95	91	94	94	96	97	97	100
		SD: 16	17	15	15	17	16	16	15
Attention Deficit/ Hyperactivity Disorders, Mixed	494	Cluster: BCA	*Gs*	*Glr*	*Ga*	*Gc*	*Gf*	*Gsm*	*Gv*
		Mdn: 95	90	93	94	96	96	97	100
		SD: 16	17	14	14	16	15	17	15
Brain Tumors, Mixed	32	Cluster: BCA	*Gs*	*Gc*	*Glr*	*Gsm*	*Ga*	*Gf*	*Gv*
		Mdn: 90	90	92	93	94	94	96	97
		SD: 15	20	17	12	14	11	14	16
Depressive Spectrum Disorder	150	Cluster: BCA	*Gs*	*Ga*	*Gf*	*Gsm*	*Glr*	*Gc*	*Gv*
		Mdn: 95	92	94	96	96	97	98	100
		SD: 16	18	13	14	17	14	17	15
Hydrocephalus	18	Cluster: BCA	*Gs*	*Gc*	*Gf*	*Glr*	*Ga*	*Gsm*	*Gv*
		Mdn: 62	66	69	76	78	81	82	89
		SD: 19	18	20	14	22	14	16	21
Impulsive/Disruptive Spectrum Disorders	73	Cluster: BCA	*Gs*	*Gc*	*Gf*	*Ga*	*Gsm*	*Glr*	*Gv*
		Mdn: 87	86	87	90	91	92	94	98
		SD: 16	19	14	16	14	17	14	17
Infectious Processes	23	Cluster: BCA	*Gs*	*Gc*	*Ga*	*Gsm*	*Glr*	*Gf*	*Gv*
		Mdn: 79	68	82	82	85	87	89	93
		SD: 20	20	20	12	16	17	21	22
Language Disorders	48	Cluster: BCA	*Gsm*	*Gc*	*Ga*	*Gs*	*Gf*	*Glr*	*Gv*
		Mdn: 78	81	82	82	84	86	88	100
		SD: 15	14	16	11	15	17	15	14

Table 3-3, cont.

			Gf–Gc Cluster by Standard Score Order						
Sample	***n***	**BCA**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Learning Disorders, Mixed	584	Cluster: BCA	*Gs*	*Glr*	*Gc*	*Ga*	*Gf*	*Gsm*	*Gv*
		Mdn: 88	86	89	91	92	93	93	98
		SD: 15	17	14	16	14	15	17	16
Mental Retardation, Mild to Profound	81	Cluster: BCA	*Gc*	*Gf*	*Gs*	*Gsm*	*Ga*	*Glr*	*Gv*
		Mdn: 56	62	66	68	71	74	75	80
		SD: 13	12	13	16	13	13	15	17
Motor Impairment	52	Cluster: BCA	*Gs*	*Glr*	*Ga*	*Gf*	*Gv*	*Gsm*	*Gc*
		Mdn: 93	90	90	95	96	96	101	102
		SD: 17	16	18	13	16	18	20	18
Neurofibromatosis	11	Cluster: BCA	*Gsm*	*Ga*	*Gc*	*Glr*	*Gs*	*Gf*	*Gv*
		Mdn: 84	85	87	87	88	89	89	97
		SD: 14	10	14	11	9	19	13	19
Pervasive Developmental Disorders	13	Cluster: BCA	*Gs*	*Gf*	*Ga*	*Gsm*	*Gc*	*Glr*	*Gv*
		Mdn: 75	72	80	80	81	87	88	93
		SD: 20	29	16	11	19	18	16	20
Seizure Disorders/Epilepsy	57	Cluster: BCA	*Gc*	*Gs*	*Glr*	*Gf*	*Gsm*	*Ga*	*Gv*
		Mdn: 83	84	85	89	89	91	92	93
		SD: 17	18	17	15	14	16	16	15
Traumatic/Closed Head Injury	170	Cluster: BCA	*Gs*	*Gc*	*Glr*	*Gsm*	*Ga*	*Gf*	*Gv*
		Mdn: 92	89	94	95	95	96	96	96
		SD: 19	21	17	18	16	15	16	18
Samples with Known Lesion Localization:									
Left Hemisphere Only	56	Cluster: BCA	*Gs*	*Glr*	*Gc*	*Ga*	*Gsm*	*Gf*	*Gv*
		Mdn: 85	84	86	87	92	92	95	97
		SD: 18	19	15	15	17	14	18	18
Right Hemisphere Only	64	Cluster: BCA	*Gs*	*Glr*	*Gc*	*Gsm*	*Gv*	*Gf*	*Ga*
		Mdn: 88	83	90	92	92	93	93	93
		SD: 18	23	19	17	18	18	14	14
Bilateral Diffuse Brain Damage	36	Cluster: BCA	*Gs*	*Glr*	*Gc*	*Gf*	*Ga*	*Gv*	*Gsm*
		Mdn: 89	88	89	90	94	95	95	96
		SD: 20	21	15	20	19	16	14	15
Anterior Cortical Lesions, Mixed	68	Cluster: BCA	*Gs*	*Gc*	*Glr*	*Ga*	*Gsm*	*Gf*	*Gv*
		Mdn: 90	86	91	92	95	96	96	98
		SD: 20	24	18	20	16	17	17	21
Posterior Cortical Lesions, Mixed	78	Cluster: BCA	*Gs*	*Glr*	*Gc*	*Gsm*	*Gf*	*Ga*	*Gv*
		Mdn: 88	82	87	89	91	92	93	94
		SD: 18	20	15	17	17	16	17	17
Frontal Lobe Lesions, Mixed	22	Cluster: BCA	*Gs*	*Gc*	*Gv*	*Glr*	*Gf*	*Ga*	*Gsm*
		Mdn: 85	76	85	85	88	88	89	90
		SD: 24	34	18	29	24	17	17	22
Temporal Lobe Lesions, Mixed	52	Cluster: BCA	*Gs*	*Glr*	*Gc*	*Gf*	*Gsm*	*Ga*	*Gv*
		Mdn: 88	85	87	87	93	93	93	97
		SD: 15	17	14	16	13	15	16	15
Parietal Lobe Lesions, Mixed	20	Cluster: BCA	*Gs*	*Glr*	*Gc*	*Gsm*	*Ga*	*Gf*	*Gv*
		Mdn: 78	72	78	78	83	84	86	92
		SD: 16	22	14	12	16	13	15	19
Subcortical/Brainstem Lesions	17	Cluster: BCA	*Gs*	*Glr*	*Gv*	*Gf*	*Ga*	*Gc*	*Gsm*
		Mdn: 83	73	86	86	86	88	89	95
		SD: 16	18	14	15	9	11	17	17

Key to Cluster Abbreviations: BCA = Broad Cognitive Ability; *Gsm* = Short-Term Memory; *Gs* = Processing Speed; *Glr* = Long-Term Retrieval; *Gv* = Visual Processing; *Gc* = Comprehension-Knowledge; *Ga* = Auditory Processing; *Gf* = Fluid Reasoning.

Table 3-4.
WJ-R Cognitive Test Score Pattern by Type of Sample (Age = 5 to 81 Years)

			Cognitive Test by Standard Score Order							
Sample	***n***	**BCA**	**1**	**2**	**3**	**4**	**11**	**12**	**13**	**14**
Reference Samples:										
Total Clinical Sample	1,315	Test: BCA	VisMat	CrsOut	MemNam	IncWrd	MemSen	AnlSyn	PicRec	VisClo
		Gf-Gc: All	*Gs*	*Gs*	*Glr*	*Ga*	*Gsm*	*Gf*	*Gv*	*Gv*
		Mdn: 90	88	91	91	93	95	96	97	100
		SD: 18	17	18	14	14	19	17	18	16
Gifted	84	Test: BCA	PicRec	IncWrd	VisClo	MemWrd	VisMat	PicVoc	AnlSyn	OrlVoc
		Gf-Gc: All	*Gv*	*Ga*	*Gv*	*Gsm*	*Gs*	*Gc*	*Gf*	*Gc*
		Mdn: 120	102	104	107	108	115	117	121	124
		SD: 11	18	14	13	16	16	15	12	14
Clinical Samples:										
Deficits in Acquired Knowledge										
Knowledge <70	56	Test: BCA	PicVoc	OrlVoc	V-A Lrn	ConFrm	MemNam	IncWrd	SndBln	VisClo
		Gf-Gc: All	*Gc*	*Gc*	*Glr*	*Gf*	*Glr*	*Ga*	*Ga*	*Gv*
		Mdn: 56	62	64	65	68	76	78	78	86
		SD: 11	11	11	19	12	14	14	11	15
Math <70	122	Test: BCA	OrlVoc	ConFrm	CrsOut	VisMat	MemNam	SndBln	IncWrd	VisClo
		Gf-Gc: All	*Gc*	*Gf*	*Gs*	*Gs*	*Glr*	*Ga*	*Ga*	*Gv*
		Mdn: 64	70	72	73	74	81	82	84	90
		SD: 14	15	13	17	13	14	13	15	15
Oral Language <70	63	Test: BCA	PicVoc	OrlVoc	ConFrm	CrsOut	SndBln	PicRec	IncWrd	VisClo
		Gf-Gc: All	*Gc*	*Gc*	*Gf*	*Gs*	*Ga*	*Gv*	*Ga*	*Gv*
		Mdn: 59	62	66	70	71	78	79	81	89
		SD: 10	12	10	12	13	12	17	13	16
Reading <70	133	Test: BCA	OrlVoc	PicVoc	CrsOut	V-A Lrn	SndBln	IncWrd	PicRec	VisClo
		Gf-Gc: All	*Gc*	*Gc*	*Gs*	*Glr*	*Ga*	*Ga*	*Gv*	*Gv*
		Mdn: 66	72	74	74	75	84	85	85	93
		SD: 15	15	18	16	16	12	14	18	15
Written Language <70	164	Test: BCA	OrlVoc	VisMat	V-A Lrn	CrsOut	SndBln	IncWrd	PicRec	VisClo
		Gf-Gc: All	*Gc*	*Gs*	*Glr*	*Gs*	*Ga*	*Ga*	*Gv*	*Gv*
		Mdn: 70	74	76	77	78	84	85	86	94
		SD: 15	16	12	16	16	14	14	17	16
Anxiety Spectrum Disorders	100	Test: BCA	VisMat	MemNam	IncWrd	PicVoc	PicRec	MemSen	AnlSyn	VisClo
		Gf-Gc: All	*Gs*	*Glr*	*Ga*	*Gc*	*Gv*	*Gsm*	*Gf*	*Gv*
		Mdn: 95	91	92	94	94	98	99	100	102
		SD: 16	16	14	13	17	16	16	16	14
Attention Deficit/ Hyperactivity Disorders, Mixed	494	Test: BCA	VisMat	IncWrd	MemNam	CrsOut	AnlSyn	PicRec	MemSen	VisClo
		Gf-Gc: All	*Gs*	*Ga*	*Glr*	*Gs*	*Gf*	*Gv*	*Gsm*	*Gv*
		Mdn: 95	89	92	92	94	98	98	99	102
		SD: 16	16	14	14	17	16	17	19	15
Brain Tumors, Mixed	32	Test: BCA	CrsOut	PicVoc	MemNam	VisMat	V-A Lrn	SndBln	AnlSyn	VisClo
		Gf-Gc: All	*Gs*	*Gc*	*Glr*	*Gs*	*Glr*	*Ga*	*Gf*	*Gv*
		Mdn: 90	90	90	93	92	96	97	98	100
		SD: 15	20	15	12	18	14	14	15	15
Depressive Spectrum Disorder	150	Test: BCA	VisMat	MemNam	CrsOut	SndBln	AnlSyn	MemSen	PicRec	VisClo
		Gf-Gc: All	*Gs*	*Glr*	*Gs*	*Ga*	*Gf*	*Gsm*	*Gv*	*Gv*
		Mdn: 95	90	94	95	95	98	98	100	100
		SD: 16	17	13	17	14	15	17	16	16

Table 3-4, cont.

			Cognitive Test by Standard Score Order							
Sample	***n***	**BCA**	**1**	**2**	**3**	**4**	**11**	**12**	**13**	**14**
Hydrocephalus	18	Test: BCA	CrsOut	VisMat	OrlVoc	PicVoc	IncWrd	VisClo	V-A Lrn	PicRec
		Gf-Gc: All	*Gs*	*Gs*	*Gc*	*Gc*	*Ga*	*Gv*	*Glr*	*Gv*
		MDN: 62	69	71	74	76	87	87	90	95
		SD: 19	17	17	21	19	14	20	26	18
Impulsive/Disruptive Spectrum Disorders	73	Test: BCA	VisMat	OrlVoc	ConFrm	MemWrd	AnlSyn	PicRec	MemNam	VisClo
		Gf-Gc: All	*Gs*	*Gc*	*Gf*	*Gsm*	*Gf*	*Gv*	*Glr*	*Gv*
		MDN: 87	87	90	90	91	93	95	96	100
		SD: 16	17	17	16	15	16	18	12	18
Infectious Processes	23	Test: BCA	VisMat	CrsOut	PicVoc	IncWrd	MemWrd	AnlSyn	PicRec	VisClo
		Gf-Gc: All	*Gs*	*Gs*	*Gc*	*Ga*	*Gsm*	*Gf*	*Gv*	*Gv*
		MDN: 79	72	76	82	85	89	92	95	99
		SD: 20	18	17	16	13	16	21	22	20
Language Disorders	48	Test: BCA	OrlVoc	MemSen	IncWrd	SndBln	V-A Lrn	MemNam	PicRec	VisClo
		Gf-Gc: All	*Gc*	*Gsm*	*Ga*	*Ga*	*Glr*	*Glr*	*Gv*	*Gv*
		MDN: 78	76	82	83	84	91	91	98	104
		SD: 15	16	15	14	12	19	14	17	12
Learning Disorders, Mixed	584	Test: BCA	VisMat	MemNam	IncWrd	CrsOut	AnlSyn	MemSen	PicRec	VisClo
		Gf-Gc: All	*Gs*	*Glr*	*Ga*	*Gs*	*Gf*	*Gsm*	*Gv*	*Gv*
		MDN: 88	86	89	90	91	95	95	90	100
		SD: 15	15	13	14	17	15	17	18	15
Mental Retardation, Mild to Profound	81	Test: BCA	PicVoc	OrlVoc	CrsOut	ConFrm	PicRec	MemNam	IncWrd	VisClo
		Gf-Gc: All	*Gc*	*Gc*	*Gs*	*Gf*	*Gv*	*Glr*	*Ga*	*Gv*
		MDN: 56	64	66	68	68	78	79	81	90
		SD: 13	14	13	18	14	20	13	14	14
Motor Impairment	52	Test: BCA	CrsOut	MemNam	VisMat	V-A Lrn	IncWrd	MemSen	PicVoc	OrlVoc
		Gf-Gc: All	*Gs*	*Glr*	*Gs*	*Glr*	*Ga*	*Gsm*	*Gc*	*Gc*
		MDN: 93	86	88	92	94	98	100	102	104
		SD: 17	17	18	15	19	14	21	18	20
Neurofibromatosis	11	Test: BCA	MemWrd	MemNam	IncWrd	V-A Lrn	CrsOut	AnlSyn	PicRec	VisClo
		Gf-Gc: All	*Gsm*	*Glr*	*Ga*	*Glr*	*Gs*	*Gf*	*Gv*	*Gv*
		MDN: 84	84	85	86	87	93	94	96	106
		SD: 14	11	9	17	13	18	13	16	18
Pervasive Developmental Disorder	13	Test: BCA	CrsOut	ConFrm	MemWrd	VisMat	V-A Lrn	PicVoc	PicRec	VisClo
		Gf-Gc: All	*Gs*	*Gf*	*Gsm*	*Gs*	*Glr*	*Gc*	*Gv*	*Gv*
		Mdn: 75	77	78	79	80	88	88	88	93
		SD: 20	30	17	16	26	20	16	26	18
Seizure Disorders/ Epilepsy	57	Test: BCA	MemNam	VisMat	PicVoc	OrlVoc	IncWrd	AnlSyn	SndBln	VisClo
		Gf-Gc: All	*Glr*	*Gs*	*Gc*	*Gc*	*Ga*	*Gf*	*Ga*	*Gv*
		MDN: 83	84	84	85	86	93	93	94	94
		SD: 17	16	16	17	19	15	15	15	16
Traumatic/Closed Head Injury	170	Test: BCA	CrsOut	VisMat	MemNam	PicVoc	IncWrd	AnlSyn	VisClo	MemWrd
		Gf-Gc: All	*Gs*	*Gs*	*Glr*	*Gc*	*Ga*	*Gf*	*Gv*	*Gsm*
		MDN: 92	90	90	92	93	97	98	98	98
		SD: 19	20	19	16	17	14	16	18	16
Samples with Known Lesion Localization:										
Left Hemisphere Only	56	Test: BCA	MemNam	PicVoc	VisMat	OrlVoc	MemWrd	PicRec	AnlSyn	VisClo
		Gf-Gc: All	*Glr*	*Gc*	*Gs*	*Gc*	*Gsm*	*Gc*	*Gf*	*Gv*
		MDN: 85	84	84	85	88	94	95	96	99
		SD: 18	14	15	17	16	14	21	16	15

Table 3-4, cont.

Sample	*n*	BCA	1	2	3	4	11	12	13	14
			Cognitive Test by Standard Score Order							
Right Hemisphere Only	64	Test: BCA	VisMat	CrsOut	MemNam	PicVoc	SndBld	V-A Lrn	AnlSyn	IncWrd
		Gf-Gc: All	*Gs*	*Gs*	*Glr*	*Gc*	*Ga*	*Glr*	*Gf*	*Ga*
		MDN: 88	84	88	88	92	94	94	95	96
		SD: 18	21	20	20	17	15	18	14	14
Bilateral Diffuse Brain Damage	36	Test: BCA	PicVoc	MemNam	CrsOut	OrlVoc	SndBln	IncWrd	AnlSyn	PicRec
		Gf-Gc: All	*Gc*	*Glr*	*Gs*	*Gc*	*Ga*	*Ga*	*Gf*	*Gv*
		MDN: 89	88	90	90	90	97	98	98	98
		SD: 20	18	15	19	24	15	16	17	13
Anterior Cortical Lesions, Mixed	68	Test: BCA	MemNam	VisMat	CrsOut	PicVoc	ConFrm	AnlSyn	PicRec	VisClo
		Gf-Gc: All	*Glr*	*Gs*	*Gs*	*Gc*	*Gf*	*Gf*	*Gv*	*Gv*
		MDN: 90	87	88	90	90	96	97	98	99
		SD: 20	19	22	23	16	18	16	21	19
Posterior Cortical Lesions, Mixed	78	Test: BCA	VisMat	MemNam	PicVoc	CrsOut	PicRec	IncWrd	AnlSyn	VisClo
		Gf-Gc: All	*Gs*	*Glr*	*Gc*	*Gs*	*Gv*	*Ga*	*Gf*	*Gv*
		MDN: 88	83	86	88	88	95	96	96	98
		SD: 18	19	16	18	19	16	16	15	16
Frontal Lobe Lesions, Mixed	22	Test: BCA	VisMat	CrsOut	MemNam	OrlVoc	AnlSyn	VisClo	MemWrd	SndBln
		Gf-Gc: All	*Gs*	*Gs*	*Glr*	*Gc*	*Gf*	*Gv*	*Gsm*	*Ga*
		MDN: 85	82	84	84	85	90	92	93	94
		SD: 24	30	34	19	19	17	23	20	18
Temporal Lobe Lesions, Mixed	52	Test: BCA	MemNam	VisMat	PicVoc	OrlVoc	PicRec	AnlSyn	MemWrd	VisClo
		Gf-Gc: All	*Glr*	*Gs*	*Gc*	*Gc*	*Gv*	*Gf*	*Gsm*	*Gv*
		MDN: 88	85	85	88	88	95	96	96	99
		SD: 15	16	17	17	17	15	13	15	15
Parietal Lobe Lesions, Mixed	20	Test: BCA	CrsOut	VisMat	PicVoc	MemNam	MemWrd	PicRec	IncWrd	VisClo
		Gf-Gc: All	*Gs*	*Gs*	*Gc*	*Glr*	*Gsm*	*Gv*	*Ga*	*Gv*
		MDN: 78	71	77	79	79	86	88	90	102
		SD: 16	19	21	13	14	19	18	16	19
Subcortical/Brainstem Lesions	17	Test: BCA	CrsOut	VisMat	V-A Lrn	PicVoc	OrlVoc	AnlSyn	MemSen	MemWrd
		Gf-Gc: All	*Gs*	*Gs*	*Glr*	*Gc*	*Gc*	*Gf*	*Gsm*	*Gsm*
		MDN: 83	81	81	82	84	92	93	94	94
		SD: 16	19	17	14	18	15	11	20	16

Key to Test Abbreviations: BCA = Broad Cognitive Ability; MemNam = Memory for Names; MemSen = Memory for Sentences; VisMat = Visual Matching; IncWrd = Incomplete Words; VisClo = Visual Closure; PicVoc = Picture Vocabulary: AnlSyn = Analysis-Synthesis; V-A Lrn = Visual-Auditory Learning; MemWrd = Memory for Words; CrsOut = Cross Out; SndBln = Sound Blending; PicRec = Picture Recognition; OrlVoc = Oral Vocabulary; ConFrm = Concept Formation.

term memory (*Gsm*), auditory processing (*Ga*), and fluid reasoning (*Gf*).

Table 3-4 adds further information about *Gf-Gc* patterns most influenced by neurological and psychiatric disorders. This table reports the four lowest and four highest of the 14 tests for each group. Again, excluding Deficits in Acquired Knowledge, median test scores range from 64 on Picture Vocabulary (a *Gc* test) in the mentally retarded group to 106 on Visual Closure (a *Gv* test) in the neurofibromatosis group. From examining this table, we see that the vast majority of the clinical groups experienced their most severe problems with the Visual Matching (*Gs*), Cross Out (*Gs*), and Memory for Names (*Glr*) tests. These tests, in large part, require attention. Such a result was not surprising because a number of studies have shown tests of attention to be adversely affected by neurological and psychiatric disorders.

Predictive Validity of the WJ-R

The history of neuropsychological assessment in North America has been characterized by a quantitative atheoretical approach. As reviewed above, this methodology was useful in establishing the credibility of clinical neuropsychology as a predictor for the presence and location of brain damage. But the new generation of radiological procedures, which began in the 1970s (e.g., CT-scan, MRI), produce clear images of the soft tissue of the brain and localized brain damage. These advances rendered neuropsychological assessment less crucial in diagnoses. However, the ability to perform analyses of patients' functional strengths and weaknesses has increased as the need for localization of damage has decreased. The WJ-R is unique in that it provides a theory based on functional assessment. Because the WJ-R was developed within *Gf-Gc* information processing theory and the definition of individual functions, one would hypothesize that the WJ-R has the potential to predict brain damage.

As shown in Table 3-5, a rather large pool of clinical data has been collected with the WJ-R. As this pool grows, a number of predictive studies will ensue. However, the present pool allows study of the WJ-R as a predictor of brain damage.

Study 1—The WJ-R as Predictor of Brain Damage

This study was designed to consider the ability of the WJ-R to predict specific brain damage as identified by an MRI, CT-scan, or surgery from subjects with medical, psychiatric, and/or central processing disorders (e.g., learning disabilities) assumed to be neurological but without clearly-defined brain damage. Using these criteria, two groups resulted: The first was a "mixed

Table 3-5.
WJ-R Prediction of Brain Damage—Discriminant Function

Sample	***n***	**Group Centroids**
Brain Damaged (MRI, CT-Scan, S)	162	–.681
Mixed (Normals, Psych, Medical, LD)	1,260	.773
Individual Tests (Stepwise)		**Standardized Function Coefficents**
Incomplete Words		–.556
Visual Closure		.306
Picture Vocabulary		.773
Analysis-Synthesis		–.689
Cross Out		.604
Wilks's Lambda		.952
Chi-Square		69.258
Significance		$p < .001$
Eigenvalue		.050

	Predicted Group	
Actual Group	**Brain Damage**	**Mixed**
Brain Damage	160	2
Mixed	2	1,258
Total Percent Hits	89.9	

Table 3-6.
WJ-R Prediction of Left-Right Hemispheric Damage

Sample	***n***	**Group Centroids**
Left Hemispheric	56	–.617
Right Hemispheric	64	.540
Individual Tests		**Standardized Functions**
Picture Vocabulary		.894
Cross Out		–.956
Memory for Names		.492
Incomplete Words		.256
Visual Closure		–.363
Visual-Auditory Learning		.062
Picture Recognition		–.347
Sound Blending		.222
Oral Vocabulary		–.266
Visual Matching		.351
Memory for Sentences		.184
Analysis-Synthesis		.053
Concept Formation		–.295
Memory for Words		–.241
Summary Statistics		
Wilks's Lambda		.747
Chi-Square		32.414
Significance		$p < .004$
Eigenvalue		.339
Total Hits		70.0%

group" of 1,260 subjects without specific evidence of brain damage and the second was a group of 162 subjects with specific evidence of brain damage. Using a discriminant analysis, which allows one to predict group membership, the tests of the WJ-R were used in a multivariate fashion. Because group sizes differed significantly ($p < .01$), groups were equalized statistically for prior probabilities.

As seen in Table 3-5, the results of the stepwise discriminant analysis showed that five of the individual WJ-R tests add significantly to the prediction of group membership. The Wilks's Lambda (.952), Chi-Square transformation (69.258) showed that tests of the WJ-R add significantly to the prediction of brain damage from other clinical subjects ($p < .001$). The standardized function coefficients provide the reader an idea of the strength and direction of individual tests in predicting group membership. The group centroids provide the reader a marker of the direction (±) for the standardized functions of the individual tests.

When each subject's actual group membership (brain damage vs. mixed) was compared with that predicted from the discriminant analysis, the WJ-R was 89.9% correct in placement. This is especially impressive when one realizes that of the mixed group only 22 of the subjects were considered "normals." As the pool of clinical subjects increases, further studies that allow cross-validation will increase the stability for individual tests of the WJ-R as predictors of neurological damage. This overall finding is noteworthy for at least two reasons. First, the predictive validity of the WJ-

R without sensory-motor information is most impressive. Indeed, other studies which have attempted to predict brain damage have relied in part on sensory-motor tests. In this study, the WJ-R, without the use of sensory-motor measures, was able to equal and, in some cases, exceed the predictive validity of other neuropsychological batteries that include sensory motor measures. Second, in regard to prediction of brain damage, these results are not significantly different from studies using neuropsychological batteries with tests chosen only for predictive value without regard for individual functions.

Early in the 20th century, success in localizing brain damage with specific behaviors led many to hypothesize that measures of specific behaviors could be devised to localize micro-areas of brain damage. Individual differences in the location of specific functions in the brain and the differences in which individual patients expressed the damage in the same locations of the brain made notions of “specific localization” archaic by today’s standards. At best, most neuropsychologists would consider a battery to be valid if it predicted the presence of brain damage and localization to a hemisphere, and perhaps anterior or posterior of the Rolandic (Central) Fissure.

Table 3-6 and Table 3-7 report two discriminant analyses. One considers prediction of the hemispheric localization of damage (Table 3-6) and the other considers the extent to which damage can be predicted as anterior or posterior to the central fissure using only the WJ-R. A direct-

Table 3-7.
WJ-R Prediction of Anterior-Posterior Brain Damage

Sample (Rolandic Fissure)	***n***	**Group Centroids**
Posterior	78	–.220
Anterior	49	.483
Individual Tests		**Standardized Functions**
Picture Vocabulary		–.789
Cross Out		–2.260
Memory for Names		–1.062
Incomplete Words		–1.388
Visual Closure		–1.354
Visual-Auditory Learning		.873
Picture Recognition		–.135
Sound Blending		–.426
Oral Vocabulary		.993
Visual Matching		1.209
Memory for Sentences		–.656
Analysis-Synthesis		–.468
Concept Formation		.438
Memory for Words		.014
Summary Statistics		
Wilks’s Lambda		.928
Chi-Square		28.87
Significance		$p < .001$
Eigenvalue		.783
Total Hits		68.6%

enter method, in which all tests are entered simultaneously, was used. In each case, the Wilks's lambda, Chi-Square transformation showed the tests of the WJ-R to predict significantly both left-right hemispheric damage and anterior-posterior damage (Table 3-7). Not only were these differences statistically significant but, in both analyses, differences were also clinically significant. As noted, this outcome is consistent and exceeds a number of studies of neuropsychological batteries that neglect the measurement of individual functions (Dean, 1986). In light of the fact that in the past the majority of predictive validity studies with batteries relied upon tests of sensory-motor functions to localize damage as left or right hemispheric and/or anterior-posterior, the present study is most impressive. One would expect improved prediction of cases when the WJ-R and the *Dean-Woodcock Sensory Motor Battery* (D-WSMB) are used in conjunction. Larger samples are necessary to allow cross-validation. As our pool grows with the WJ-R and the D-WSMB, publications and further research reports will be made available. However, the present data are most encouraging as to the validity and utility of the WJ-R as a measure of neuropsychological function.

Table 3-8 provides evidence that the WJ-R tests significantly discriminate groups with closed head injury and brief loss of consciousness from those with a psychiatric diagnosis of depression and/or anxiety. In this study, a discriminant analysis was used with all tests of the WJ-R entered as predictors. The Wilks's lambda, Chi-Square transformation showed the

Table 3-8.
WJ-R Prediction of CHI and Psychiatric Patients

Sample	***n***	**Group Centroids**
Closed Head Injury	171	–.319
Psychiatric Patients	61	.910
Individual Tests		**Standardized Functions**
Memory for Names		.105
Memory for Sentences		.462
Visual Matching		–.846
Incomplete Words		–.640
Picture Vocabulary		.098
Analysis-Synthesis		.115
Visual-Auditory Learning		.195
Memory for Words		–.286
Cross Out		1.109
Sound Blending		.111
Picture Recognition		–.022
Oral Vocabulary		.028
Concept Formation		–.373
Visual Closure		.632
Summary Statistics		
Wilks's Lambda		.773
Chi-Square		52.172
Significance		$p < .001$
Eigenvalue		.293
Total Hits		81.2%

14 tests were able to predict actual group membership with 81.2% accuracy. This study is of special interest because many of the symptoms frequently resulting from a closed head injury (post-concussive disorder) are psychiatric/emotional in nature. Again, cross-validation is needed; however, the results suggest memory impairment to be a more potent predictor of a closed head injury than of a psychiatric disorder, in which inattention seems more salient. This finding not only offers validity of the WJ-R as an important measure in neuropsychological assessment, but also extends our knowledge of closed head injuries.

Clinical Cases

This section offers the reader an appreciation of the variety of clinical purposes for the D-WNAS. The WJ-R and Batería-R provide the taproot for assessing a breadth of behavioral functions not offered through any other single battery. With an examination of the Dean-Woodcock Cognitive Neuropsychological Model shown in Figure 1-1, it becomes clear that Woodcock's (1993) extended *Gf-Gc* theory offers an information processing model that combines theory with dimensions of input and output. The WJ-R, in conjunction with this model, gives neuropsychologists and clinicians interested in defining cognitive strengths and weaknesses both a means of assessment and a method of interpretation. As portrayed in Table 3-9, scores from the WJ-R may be transformed in a number of ways. One transformation that holds considerable interest in neuropsychology is described as "Functional Level." When Table 3-9 is consulted, scores from individual tests of the WJ-R and Batería-R may be transformed to functional levels ranging from "Advanced" to "Severely Impaired." Because these terms are based on the results of Rasch scaling, they have the same meaning at any age level and for any area measured (Woodcock, 1999, pp. 199–121). In addition to this breadth of coverage, the wide band norming of the WJ-R allows the evaluation of subjects ranging in age from 2 to 90 years.

The addition of the D-WSMB offers further information concerning the peripheral and central nervous system functions not measured directly by the WJ-R and the Batería-R. The D-WSMB also allows scoring that ranges from "Within Normal Limits" to "Severely Impaired." The D-WSMB provides information on the input and output of sensory and motor functions in addition to a formal assessment of important facilitator-

Table 3-9.
Neuropsychological Functional Level/Deficits and Predicted Performance

RPI	*W* Difference Score	Functional Level	Patient Will Find the Demands of Related Age Level Tasks:
97/90 to 100/90	+11 and above	Advanced	Very Easy
75/90 to 96/90	–10 to +10	Adequate	Manageable
25/90 to 74/90	–30 to –11	Mildly Impaired	Very Difficult
4/90 to 24/90	–50 to –31	Moderately Impaired	Extremely Difficult
0/90 to 3/90	–51 and below	Severely Impaired	Impossible

inhibitors.

In an effort to offer the reader an appreciation of the D-WNAS, a number of clinical cases have been chosen to demonstrate the clinical utility of the approach. The ages of the patients range from 8 to 76 years and represent a range of neurologic and psychiatric disorders.

The neuropsychologist experienced with other batteries will find many of these cases of interest because they illuminate the limitations of other batteries. That is, because the WJ-R's cognitive processing tends to measure individual functions, patients for whom the experienced neuropsychologist would expect impairment on all tests will find relative strengths not seen in other neuropsychological batteries.

Case 1: Scott J.

Scott J. is 8 years and 9 months old. He is a right-handed white male who was functioning in the B–C grade range in a regular third-grade classroom. The patient's chief complaints involved distractibility, inattention, and hyper-motor behavior at home and school. However, fewer problems were observed at home. Information from the Structured Interview failed to indicate any past illnesses, injuries, or surgeries. Present medical conditions, medications, and psychological/psychiatric treatment were denied. The patient was the product of a full-term standard vaginal delivery. Perinatal complications were denied, and the patient weighed 7 lb. 3 oz. at birth. The patient lives with his biological mother and father and 4-year-old brother. A family history of clinical depression, anxiety, and learning disabilities was reported by his mother.

The results shown in Table 3-10 indicate the patient's general intellectual function, or Broad Cognitive Ability, was in the above average range. In general, academic achievement was consistent with his Broad Cognitive Ability with the exception of applied quantitative problems, handwriting, and passage comprehension. The difference between Broad Cognitive Ability and these results of achievement were not significant.

From a general neuropsychological or processing point of view, Scott's performance was within normal limits. However, moderate impairment was noted in Processing Speed (*Gs*) and Short-Term Memory (*Gsm*). Mild impairment was found bilaterally in tactile perception with the aid of vision. The results of the Mental Status Exam showed moderate levels of hyper-motor behavior, inattention, and distractibility with some mild depression.

In summary, Scott is a bright child with some specific academic problems; however, in each case these difficulties seem secondary to attention, hyper-motor behavior, and distractibility. This emotional/behavioral inhibitor is also clear in his impairment in Processing Speed (Gs) and Short-Term Memory (Gsm). Problems found in bilateral tactile perception are often seen in patients with inattention or anxiety who respond in an impulsive manner.

This case illustrates the need to consider or rule out facilitator-inhibitors as important factors affecting cognitive and sensory-motor functions. Indeed, this patient, from the data presented here, was diagnosed with an Attention-Deficit Hyperactivity Disorder—Active type with an overlay of depression. The patient was referred back to his pediatrician with a recommendation to consider psychoactive medication.

Table 3-10.
Case Study: Scott J.

Name: Scott J.	Handedness: Rt.
Gender: Male	Diagnosis: None
Age: 8-9	Time Since Onset: N/A
Education: 3rd/Current/Reg. Ed.	

Broad Cognitive Ability (BCA)	**112**
Short-Term Memory	
Memory for Sentences	Moderate
Memory for Words	WNL
Picture Recognition (Visual Memory)	Adequate
Processing Speed	
Visual Matching	Moderate
Cross Out	Moderate
Oral Language (Verbal-Conceptual Knowledge)	
Picture Vocabulary	WNL
Oral Vocabulary	WNL
Expressive Speech	WNL
Quantitative Knowledge	
Calculation	WNL
Applied Problems	Mild
Reading/Writing	
Spelling and Dictation	WNL
Handwriting	Mild
Passage Comprehension	Mild
Letter-Word Identification	WNL
Visual-Spatial Thinking	
Visual Closure	Mild
Picture Recognition	WNL
Auditory Processing	
Sound Blending	Mildly Impaired
Sound Patterns	Adequate
Incomplete Words	WNL
Long-Term Storage-Retrieval	
Memory for Names	Adequate
Visual-Auditory Learning	WNL
Novel Reasoning	
Concept Formation	WNL
Spatial Relations	WNL
Verbal Analogies	WNL
Analysis-Synthesis	Adequate
Sensory Assessment	
Near Point Visual Acuity	WNL
Visual Confrontation	WNL
Naming Pictures of Objects	WNL
Auditory Perception	WNL
Tactile Perception	Mild Bilateral
Motor Assessment	
Gait and Station	WNL
Romberg	WNL
Coordination/Gross Cerebellar Assessment	Low Normal
Construction	Low Normal
Mime Movements	WNL
Left-Right Movements	WNL
Finger Tapping	WNL
Grip Strength	WNL
History/Emotional Status	
History (Medical, Psychiatric, Social, Family)	FA Hx; Depression, Anxiety, LD
Mental Status	Inattention, Distractability, Hypermotor

WNL = Within Normal Limits

Case 2: Tina C.

Tina C. is a 30-year-old, right-handed, divorced, white female. She was a high school graduate who was referred by her neurologist for a neuropsychological evaluation. Eight months prior to being seen, the patient suffered a closed head injury as the result of a motor vehicle accident. The patient was reported to have lost consciousness for some two hours. MRIs of the brain were negative. However, a recent EEG showed mild impairment (abnormal diffuse slowing). The patient's major complaints involved headache, depression, and memory loss since the accident.

The patient's Structural Interview showed a negative premorbid history for psychiatric treatment, medical illness, and injury. Five years ago the patient was married for three years, has no children, and lives alone. The patient graduated in four years from high school in the upper 1/3 of her

Table 3-11.
Case Study: Tina C.

Name: Tina C.	Handedness: Rt.
Gender: Female	Diagnosis: CHI with 2HR LOC
Age: 30	Time Since Onset: 8 months
Education: HSG	

Broad Cognitive Ability (BCA)	**91**
Short-Term Memory	
Memory for Sentences	Moderate
Memory for Words	Mild
Picture Recognition (Visual Memory)	WNL
Processing Speed	
Visual Matching	Mild
Cross Out	Moderate
Oral Language (Verbal-Conceptual Knowledge)	
Picture Vocabulary	WNL
Oral Vocabulary	WNL
Expressive Speech	WNL
Quantitative Knowledge	
Calculation	Adequate
Applied Problems	Adequate
Reading/Writing	
Spelling and Dictation	WNL
Handwriting	WNL
Passage Comprehension	WNL
Letter-Word Identification	WNL
Visual-Spatial Thinking	
Visual Closure	Adequate
Picture Recognition	WNL
Auditory Processing	
Sound Blending	WNL
Sound Patterns	WNL
Incomplete Words	Adequate
Long-Term Storage-Retrieval	
Memory for Names	Moderate
Visual-Auditory Learning	Moderate
Novel Reasoning	
Concept Formation	Moderate
Spatial Relations	Moderate
Verbal Analogies	Mild
Analysis-Synthesis	Moderate
Sensory Assessment	
Near Point Visual Acuity	WNL
Visual Confrontation	WNL
Naming Pictures of Objects	WNL
Auditory Perception	WNL
Tactile Perception	Mild (Rt.)
Motor Assessment	
Gait and Station	WNL
Romberg	WNL
Coordination/Gross Cerebellar Assessment	Low Normal
Construction	WNL
Mime Movements	WNL
Left-Right Movements	Low Normal
Finger Tapping	Mild (Rt.)
Grip Strength	Mild (Rt.)
History/Emotional Status	
History (Medical, Psychiatric, Social, Family)	HA, Depression, Memory Loss
Mental Status	Anxiety, Depression
Medication	Paxil 20 mg. qam

WNL = Within Normal Limits

class and had no learning problems. Since the motor vehicle accident, the patient has not been able to return to work as a computer entry operator. The patient is being treated by a neurologist for headaches and depression. When seen, the patient was taking Paxil (an antidepressant) 20 mg once in the morning and Midrin as needed.

Results of the Mental Status Exam showed the patient to have clinical levels of depression, anxiety, and confusion. She denied suicidal thoughts but reported that the anxiety and depression began soon after the accident. In addition, the patient admitted a moderate memory loss from the accident and present loss for short term, long term, and intermediate events.

As shown in Table 3-11, Tina's Broad Cognitive Ability was in the low average range. This outcome was congruent with the patient's remote memory for skills usually associated with formal schooling. Overall, the patient's neuropsychological functioning was in the mild to moderately impaired range, with cognitive aspects of the WJ-R most clearly impaired. Indeed, the patient was impaired in all measures of Novel Reasoning (*Gf*), Long-Term Storage Retrieval (*Glr*), most measures of Short Term Memory (*Gsm*), and Processing Speed (*Gs*). Sensory-motor functioning was marked by mildly impaired motor and tactile performance on the right side. This is a rather complex case in which emotional and social factors may play a role. Further complication is added by the fact that the patient's head injury occurred only 8 months ago. Therefore, an unknown amount of spontaneous recovery may be expected up to two years following the accident.

The patient would benefit from a review of her psychoactive medication. Moreover, the patient's anxiety, confusion, and depression all serve to inhibit complex *Gf* functions. Hopefully, with more attention to medication, improvements in cognitive functions will occur. However, this is not clear from the patient's present data. At this time, the patient's diagnosis is consistent with a Post-Concussive Syndrome with depressive features. The

Table 3-12.
Case Study: Edith G.

Name: Edith G.	Handedness: Rt.
Gender: Female	Diagnosis: Left Hemispheric CVA
Age: 76	Time Since Onset: 21 months
Education: HSG	

Broad Cognitive Ability (BCA)	**67**
Short-Term Memory	
Memory for Sentences	Moderate
Memory for Words	Mild
Picture Recognition (Visual Memory)	Adequate
Processing Speed	
Visual Matching	Mild
Cross Out	Moderate
Oral Language (Verbal-Conceptual Knowledge)	
Picture Vocabulary	WNL
Oral Vocabulary	WNL
Expressive Speech	Adequate
Quantitative Knowledge	
Calculation	Adequate
Applied Problems	Mild
Reading/Writing	
Spelling and Dictation	Adequate
Handwriting	Mild
Passage Comprehension	Mild
Letter-Word Identification	Adequate
Visual-Spatial Thinking	
Visual Closure	Adequate
Picture Recognition	WNL
Auditory Processing	
Sound Blending	Mild
Sound Patterns	Mild
Incomplete Words	Mild
Long-Term Storage-Retrieval	
Memory for Names	Mild
Visual-Auditory Learning	Adequate
Novel Reasoning	
Concept Formation	Moderate
Spatial Relations	Mild
Verbal Analogies	Moderate
Analysis-Synthesis	Moderate
Sensory Assessment	
Near Point Visual Acuity	WNL
Visual Confrontation	Rt. Field Cut
Naming Pictures of Objects	Mild
Auditory Perception	WNL
Tactile Perception	Mild (Rt.)
Motor Assessment	
Gait and Station	Mild (Rt.)
Romberg	WNL
Coordination/Gross Cerebellar Assessment	Low Normal
Construction	Mild
Mime Movements	WNL
Finger Tapping	Severe (Rt.)
Grip Strength	Severe (Bilateral)
History/Emotional Status	
History (Medical, Psychiatric, Social, Family)	CVA (Lt.); Family History—DAT
Mental Status	Anxiety, Inattention, Depression

WNL = Within Normal Limits

patient should be re-examined in six months to a year, following stabilization of medication and an opportunity for spontaneous recovery. A referral for individual counseling is suggested.

Case 3: Edith G.

Edith G. is a 76-year-old, right-handed, widowed female who suffered a left-hemispheric stroke some 21 months ago and continues to report language impairment, as well as cognitive and sensory motor deficits.

The patient's premorbid medical and psychiatric history were unremarkable. The patient did report having a hysterectomy 20 years ago. She admitted to taking "nerve pills" 10 years ago following the death of her husband. The patient has two grown children who live out of state. She resides with her younger sister. Prior to her retirement, the patient held a number of clerical jobs and retired from state employment as an administrative aid after 25 years of service.

The patient's Broad Cognitive Ability was in the borderline range which would seem to represent a depression from her past employment and many of her present stores of declarative knowledge (e.g., Picture Vocabulary, Quantitative Ability).

From a neuropsychological point of view, the patient is presented with moderate to severe impairment of functions. Specifically, fluid memory, verbal memory, and verbal expressiveness were in the moderately impaired range. In addition, the Sensory-Motor Exam showed a right visual field deficit as well as a number of right-sided severe sensory and motor deficits. These data are consistent with diffuse impairment, however those functions most often seen as left hemispheric were most clearly indicated. The extent of the impairment suggests that the patient would not be able to care for herself. In addition, the severe nature of the patient's motor impairment suggests the need for therapy to reduce pain and maintain range of motion.

The patient's Mental Status Exam indicated clinical levels of anxiety, inattention, and depression. The patient was not taking any medication (other than one aspirin per day) when seen. She should be considered for a psychotropic medication for depression and anxiety. In sum, these data are consistent with a left hemispheric stroke with an overlay of anxiety and depression. Although the patient has a family history of dementia, the strengths present here rule out this diagnosis.

Case 4: Betty E.

Betty E. is a 69-year-old, right-handed, married, white female with one year of college in accounting. The patient has a long-standing diagnosis of depression which has been treated by her family practitioner with Prozac 40 mg each evening. Although her family practitioner believes her depression is under control, she was referred for memory loss, dysnomia, and confusion.

Other than a history of depression, mild hypertension, and the removal of the patient's tonsils and adenoids at the age of six, her premorbid medical history was unremarkable. During the Structured Interview, with the patient's husband present, it was made clear that the patient's problems with memory, confusion, and dysnomia were first recognized two

Table 3-13.
Case Study: Betty E.

Name: Betty E.	Handedness: Rt.
Gender: Female	Diagnosis: Depression by Hx
Age: 69	Time Since Onset: 8 years
Education: 1 Yr. College	

Broad Cognitive Ability (BCA)	**83**
Short-Term Memory	
Memory for Sentences	Moderate
Memory for Words	Moderate
Picture Recognition (Visual Memory)	Mild
Processing Speed	
Visual Matching	Mild
Cross Out	Mild
Oral Language (Verbal-Conceptual Knowledge)	
Picture Vocabulary	Mild
Oral Vocabulary	Mild
Expressive Speech	Mild
Quantitative Knowledge	
Calculation	WNL
Applied Problems	Mild
Reading/Writing	
Spelling and Dictation	WNL
Handwriting	WNL
Passage Comprehension	Mild
Letter-Word Identification	WNL
Visual-Spatial Thinking	
Visual Closure	Mild
Picture Recognition	Mild
Auditory Processing	
Sound Blending	Mild
Sound Patterns	Mild
Incomplete Words	Mild
Long-Term Storage-Retrieval	
Memory for Names	Moderate
Visual-Auditory Learning	Moderate
Novel Reasoning	
Concept Formation	Severe
Spatial Relations	Mild
Verbal Analogies	Moderate
Analysis-Synthesis	Severe
Sensory Assessment	
Near Point Visual Acuity	WNL
Visual Confrontation	WNL
Naming Pictures of Objects	Low Normal
Auditory Perception	WNL
Tactile Perception	WNL
Motor Assessment	
Gait and Station	WNL
Romberg	WNL
Coordination/Gross Cerebellar Assessment	WNL
Construction	Mild
Mime Movements	WNL
Finger Tapping	WNL
Grip Strength	WNL
History/Emotional Status	
History (Medical, Psychiatric, Social, Family)	Depression Controlled Prozac 40 mg qam
Mental Status	Inattention, Confusion

WNL = Within Normal Limits

years ago and have exacerbated such that the patient's husband fears leaving her alone.

The patient's overall cognitive functioning was in the moderately impaired range. Her Broad Cognitive Ability was less than would have been expected by education and background. A *Gf-Gc* difference was quite clear. Functions such as Novel Reasoning (*Gf*) and Memory were generally in the moderately impaired range. However, in performance of skills which require declarative stores and sensory-motor functions, she showed relatively little impairment. The patient's Mental Status Exam showed clinical anxiety and inattention. Depression seems fairly well controlled. The patient did have mild confusion and dysnomia.

This pattern is consistent with a progressive dementia disorder probably of the Alzheimer's type. With a dementia disorder such as this, a patient would generally show few if any strengths with other neuropsychological batteries because functions measured by these tests are so interdependent that impaired areas mask areas of strength.

References

Albert, M. S. (1988). Assessment of cognitive dysfunction. In M. S. Albert & M. Moss (Eds.), *Geriatric neuropsychology* (pp. 57–81). New York: Guilford Press.

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, DC: Author.

Arcenaux, J. M., Hill, S. K., Chamberlain, C. M., & Dean, R. S. (1997). Developmental and sex differences in sensory and motor functioning. *International Journal of Neuroscience, 89,* 253–263.

Bender, M. B. (1952). *Disorders in perception.* Springfield, IL: Charles C. Thompson.

Boll, T. J. (1976). Behavioral correlates of cerebral damage in children aged 9–14. In R. M. Reitan & L. A. Davison (Eds.), *Clinical neuropsychology: Current status and applications.* New York: Wiley.

Boll, T. J. (1987). The role of neuropsychology in the general practice of child and adolescent psychology. *Journal of Child and Adolescent Psychotherapy, 4,* 13–18.

Buchanan, R. W., & Heinrichs, D. W. (1989). The Neurological Evaluation Scale (NES): A structured instrument for the assessment of neurological signs in schizophrenia. *Psychiatric Research, 27,* 335–350.

Cantwell, D. P. (1996). Attention deficit disorder: A review of the past 10 years. *Journal of the American Academy of Child and Adolescent Psychiatry, 35,* 978–987.

Carroll, J. B. (1993). *Human Cognitive Abilities: A survey of factor-analytic studies.* New York: Cambridge University Press.

Carroll, J. B. (1998). Human Cognitive Abilities: A critique. In J. J. McArdle & R. W. Woodcock (Eds.), *Human cognitive abilities in theory and practice* (pp. 5–24). Mahwah, NJ: Lawrence Erlbaum Associates.

Cicchetti, D. V. (1976). Assessing inter-rater reliability for rating scales: Resolving some basic issues. *British Journal of Psychiatry, 129,* 452–456.

Cicchetti, D. V. (1988). When diagnostic agreement is high, but reliability is low: Some paradoxes occurring in joint independent neuropsychology assessments. *Journal of Clinical and Experimental Neuropsychology, 10,* 605–622.

Cicchetti, D. V., Volkmar, F., Sparrow, S. S., Cohen, D., Fermanian, J., & Rourke, B. P. (1992). Assessing the reliability of clinical scales when the data have both nominal and ordinal features: proposed guidelines for neuropsychological assessments. *Journal of Clinical and Experimental Neuropsychology, 14,* 673–686.

Dean, R. S. (1986). Perspectives on the future of neuropsychological assessment. In J. V. Mitchell (Series Ed.), B. S. Plake, & J. C. Witt (Vol. Eds.), *Buros-Nebraska symposium on measurement and testing:*

Vol. 2. The future of testing (pp. 203–244). Hillsdale, NJ: Earlbaum.

Dean, R. S. (1987). Foundations of rationale for neuropsychological bases of individual differences. In L. C. Hartlage & C. F. Telzrow (Eds.), *The neuropsychology of individual differences: A developmental perspective*. New York: Plenum Press.

Dean, R. S. (1989). Perspectives on the future of neuropsychological assessment. In B. S. Plake and J. C. Witt (Eds.), *Buros-Nebraska Series on Measurement and Testing.* New York: Lawrence Erlbaum Associates.

Dean, R. S., & Gray, J. W. (1990). Traditional approaches to neuropsychological assessment. In T. B. Gutkin & C. Reynolds (Eds.), *The Handbook of School Psychology* (pp. 269–288). New York: John Wiley & Sons.

Dean, R. S. & Woodcock, R. W. (in preparation). *Dean-Woodcock Neuropsychological Assessment System*. Itasca, IL: Riverside Publishing.

Dean, R. S., & Woodcock, R. W. (in preparation). *Dean-Woodcock Sensory Motor Battery.* Itasca, IL: Riverside Publishing.

Dodril, C. B. (1979). Sex differences on the *Halstead-Reitan Neuropsychological Battery* and on other neuropsychological measures. *Journal of Clinical Psychology, 35,* 236–241.

Fairweather, H. (1976). Sex differences in cognition. *Cognition*, *4*, 231–280.

Franzen, M. D. (1989). *Reliability and validity in neuropsychological assessment*. New York: Plenum Press.

Geschwind, N. (1975). The apraxias: Neuronal mechanisms of disorders of learned movement. *American Scientist, 63,* 188–195.

Golden, C. J., Purish, A. D., & Hammeke, T. A. (1985). *Luria-Nebraska Neuropsychological Battery.* Los Angeles: Western Psychological Services.

Goldstein, K. H. (1942). *After effects of brain injuries in war.* New York: Grune & Stratton.

Hill, S. K., Lewis, M., Dean, R. S., & Woodcock, R. W. (in press). Constructs underlying measures of sensory-motor functions. *Archives of Clinical Neuropsychology.*

Hom, J., & Reitan, R. M. (1984). The Halstead-Reitan Battery as a predictor of brain damage. In R. M. Reitan & L. M. Davidson (Eds.), *Clinical neuropsychology: Current status and applications*. New York: Wiley.

Horn, J. L. (1988). Thinking about human abilities. In J. R. Nesselroade & R. B. Cattell (Eds.), *Handbook of multivariate psychology–Revised* (pp. 645–685). New York: Academic Press.

Horn, J. L. (1991). Measurement of intellectual capabilities: A review of theory. In K. S. McGrew, J. K. Werder, & R. W. Woodcock, *WJ-R technical manual* (pp. 197–232). Itasca, IL: Riverside Publishing.

Horton, A. M., & Puente, A. E. (1986). Human neuropsychology: An overview. In D. Wedding, A. M. Horton, & J. Webster (Eds.), *The neuropsychology handbook: Behavioral and clinical perspectives* (pp. 3–22). New York: Springer Publishing Company.

Huttenlocher, P. R., Levine, S. C., Huttenlocher, J., & Gates, J. (1990). Discrimination of normal and at-risk preschool children on the basis of neurological test. *Developmental Medicine and Child Neurology, 32,* 394–402.

Hynd, G. W., & Willis, W. G. (1988). *Pediatric neuropsychology.* Philadelphia: Grune and Stratton, Inc.

Kolb, B., & Whishaw, I. Q. (1990). *Fundamentals of neuropsychology* (3rd ed.). New York: W. H. Freeman.

Kolb, B., & Wishaw, I. Q. (1996). *Fundamentals of neuropsychology* (4th ed.). New York: W. H. Freeman.

Lang, D., Hill, K., & Dean, R. S. (in preparation). *Developmental factors in sensory-motor functioning.*

Lloyd, B. B., & Archer, J. (1976). *Exploring sex differences.* New York: Academic Press.

Luria, A. R. (1963). *Restoration of function after brain injury.* New York: MacMillan.

Luria, A. R. (1966). *Higher cortical functions in man.* New York: Basic Books.

Luria, A. R. (1970). The functional organization of the brain. *Scientific American, 3,* 66–78.

Luria, A. R. (1973). *The working brain.* London: Penguin Press.

Luria, A. R., & Majovski, L.V. (1977). Basic approaches used in American and Soviet clinical neuropsychology. *American Psychologist, 32,* 959–968.

McGrew, K. S., Werder, J. K., & Woodcock, R. W. (1991). *WJ-R Technical Manual: A reference on theory and current research.* Itasca, IL: Riverside Publishing.

Parsons, P., & Prigatano, G. (1978). Methodological considerations in clinical neuropsychological research. *Journal of Consulting and Clinical Psychology, 46,* 1554.

Pedhazur, E. J., & Schmelkin, L. P. (1991). *Measurement, design, and analysis: An Integrated approach.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Peters, J. E., Romine, J. S., & Dykman, R. A. (1975). A special neurological examination of children with learning disabilities. *Developmental Medicine and Child Neurology, 17,* 63–78.

Piaget, J. (1952). *The origins of intelligence in children.* New York: Norton.

Rasch, G. (1960). *Probabilistic models for some intelligence and attainment tests.* Copenhagen, Denmark: Danish Institute for Educational

Research.

Rasmussen, P., Gillberg, C., Waldenstrom, E., & Svenson, B. (1983). Perceptual, motor and attentional deficits in seven-year-old children: Neurological and neurodevelopmental aspects. *Developmental Medicine and Child Neurology, 25,* 315–333.

Reitan, R. M. (1955). An investigation of the validity of Halstead's measures of biological intelligence. *Archives of Neurology and Psychiatry, 73,* 28–35.

Reitan, R. M. (1966). Problems and prospects in studying the psychological correlates of brain lesions. *Cortex, 2,* 127–154.

Reitan, R. M. (1974). Methodological problems in clinical neuropsychology. In R. M. Reitan & L. A. Davison (Eds.), *Clinical neuropsychology: Current status and applications.* New York: Wiley & Sons.

Reitan, R. M., & Davidson, L. A. (1974). *Clinical neuropsychology: Current status and applications.* New York: Wiley & Sons.

Reitan, R. M., & Wolfson, D. (1993). *The Halstead-Reitan Neuropsychological Test Battery.* Tucson, AZ: Neuropsychology Press.

Richards, M., Bell, K., Dooneief, G., Marder, K., Sano, M., Mayeux, R., & Stern, Y. (1993). Patterns of neuropsychological performance in Alzheimer's disease patients with and without extrapyramidal signs. *Neurology, 43,* 1708–1711.

Rockford, J. M., Detre, T., Tucker, G. T., & Harrow, O. K. (1970). Neuropsychological impairments in functional psychiatric diseases. *Archives of General Psychiatry, 22,* 114–118.

Shrout, P. E., Spitzer, R. L., & Fleiss, J. L. (1987). Quantification of agreement in psychiatric diagnosis revisited. *Archives of General Psychiatry, 44,* 172–177.

Wilson, R. S., Rosenbaum, G., Brown, G., Rourke, D., Whitman, D., & Grisell, J. (1978). An index of premorbid intelligence. *Journal of Consulting in Clinical Psychology, 46,* 1554–1563.

Woodcock, R. W. (1990). Theoretical foundations of the WJ-R measures of cognitive ability. *Journal of Psychoeducational Assessment, 8,* 231–258.

Woodcock, R. W. (1993). An information processing view of Gf-Gc theory. *Journal of Psychoeducational Assessment* [Monograph Series: WJ-R Monograph], 80–102.

Woodcock, R. W. (1994). Measures of fluid and crystallized theory of intelligence. In J. R. Sternberg (Ed.), *Encyclopedia of human intelligence* (pp. 452–456). New York: Macmillan.

Woodcock, R. W. (1998). *The WJ-R and Batería-R in neuropsychological assessment: Research report number 1.* Itasca, IL: Riverside Publishing.

Woodcock, R. W. (1999). What can Rasch-based scores convey about a person's test performance? In S. E. Embretson & S. L. Hershberger (Eds.), *The new rules of measurement: What every psychologist and educator should know* (pp. 105–127). Mahwah, NJ: Lawrence

Erlbaum Associates.

Woodcock, R. W., & Johnson, M. B. (1989a). *Woodcock-Johnson–Revised Tests of Achievement.* Itasca, IL: Riverside Publishing.

Woodcock, R. W., & Johnson, M. B. (1989b). *Woodcock-Johnson–Revised Tests of Cognitive Ability.* Itasca, IL: Riverside Publishing.

Woodcock, R. W., & Munoz-Sandoval, A. F. (1996a). *Batería Woodcock-Munoz: Pruebas de aprovechamiento–Revisada.* Itasca, IL: Riverside Publishing.

Woodcock, R. W. & Munoz-Sandoval, A. F. (1996b). *Batería Woodcock-Munoz: Pruebas de habilidad cognitiva–Revisada.* Itasca, IL: Riverside Publishing.

Woodward, H. R., Ridenour, T., & Dean, R. S. (in preparation). *Reliability of traditional neurological sensory and motor tests.*

Wright, B. D., & Stone, M. H. (1979). *Best test design.* Chicago: MESA Press.