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Essential Elements for Assessment of Persons with Severe Neurological Impairments for Computer Access Using Assistive Technology Devices: A Delphi Study

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To the Graduate Council:

I am submitting herewith a dissertation written by Brian Scott Hoppestad entitled "Essential Elements for Assessment of Persons with Severe Neurological Impairments for Computer Access Using Assistive Technology Devices: A Delphi Study." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Education, with a major in Instructional Technology and Educational Studies.

Edward L. Counts, Major Professor

We have read this dissertation and recommend its acceptance:

John R. Ray, Michael C. Hannum, C. Glennon Rowell

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Acceptance for the Council:

Anne Mayhew
Vice Chancellor and Dean
of Graduate Studies

(Original signatures are on file with official student records.)

ESSENTIAL ELEMENTS FOR ASSESSMENT OF PERSONS WITH SEVERE NEUROLOGICAL IMPAIRMENTS FOR COMPUTER ACCESS USING ASSISTIVE TECHNOLOGY DEVICES: A DELPHI STUDY

A Dissertation
Presented for the
Doctor of Education
Degree
The University of Tennessee, Knoxville

Brian Scott Hoppestad
May, 2004

DEDICATION

I dedicate this study to my wife Donna and my children Alex and Anna who have exhibited the utmost patience, and have sacrificed on innumerable occasions to allow me the time and vigor required to complete my studies. To my parents, Jean and Lamont, who have been staunchly supportive of me throughout all my educational endeavors. To my in-laws Marvin and Anne, who have graciously offered their assistance and support. In memory of Ruby Gray a remarkable person, a tremendous educator, and an inspiration to all.

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ABSTRACT

This study was undertaken with the intention of determining potential elements for inclusion in an assessment of persons with disabilities for access to computers utilizing assistive technology (AT). There is currently a lack of guidelines regarding areas that constitute a comprehensive and valid measure of a person's need for AT devices to enable computer access, resulting in substandard services. A list of criteria for elements that should be incorporated into an instrument for determining AT for computer access was compiled from a literature review in the areas of neuroscience, rehabilitation, and education; and a Delphi study using an electronic survey form that was e-mailed to a panel of experts in the field of AT. The initial Delphi survey contained 22 categories (54 subcategories) and elicited 33 responses. The second round of the survey completed the Delphi process resulting in a consensus by the panel of experts for inclusion of 39 subcategories or elements that could be utilized in an assessment instrument. Only those areas rated as essential to the assessment process (very important or important by 80% of the respondents) were chosen as important criteria for an assessment instrument. Many of the non-selected elements were near significance, were studied in the literature, or were given favorable comments by the expert panelists. Other areas may be redundant or could be subsumed under another category. There are inherent obstacles to prescribing the proper AT device to assist disabled persons with computer access due to the complexity of their conditions. There are numerous technological devices to aid persons in accomplishing diverse tasks. This study reveals the complexity of the assessment process, especially in persons with severe disabilities associated with neurological

conditions. An assessment instrument should be broad ranging considering the multidimensional nature of AT prescription for computer access. Both intrinsic and extrinsic factors affect the provision of AT.

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CHAPTER I

INTRODUCTION AND GENERAL BACKGROUND INFORMATION

Introduction

Historically, persons with severe and multiple disabilities have in effect, been ostracized from full inclusion and involvement in society. Repeatedly, these individuals were not only treated as inferior to others and sometimes worthless, but families were made to feel disgraced or ashamed of these persons. As a matter of course, physicians, other family members, and friends encouraged the parents or caregivers of severely disabled children or adults to institutionalize him/her. The facilities charged with guardianship of the disabled afforded scarcely more than custodial care, and were typically environments with deplorable living conditions. If one were to research the recent past to determine the treatment of individuals with all types of disabilities—both mental and physical—one would find abuse, neglect, stereotypes, prejudice, alienation, and a general lack of support, compassion, and integration of these persons into our culture (History of Persons with Disabilities, n.d.; Promoting Change: A Brief History of Persons with Disabilities, n.d.). Moreover, if disabled individuals basic needs were met, often everything was done for them resulting in a state of passivity or what has been termed "learned helplessness."

Not until recently have societal attitudes been reshaped toward persons with disabilities. Legislation has been instituted to preclude discriminatory practices and allow opportunities for this population. These legislative measures with their entitlements have not completely resolved the barriers faced by disabled persons in contemporary society with regard to full inclusion in our culture. However, current laws—in conjunction with improved scientific knowledge and social activism— have paved the way for increased accessibility in activities of daily living, education, work, and leisure for disabled individuals. Another area that has advanced the cause of civil rights for the disabled and allowed him/her opportunities, henceforth thought unobtainable, is the rapid evolution of technologies such as the personal computer. Numerous technological devices have emerged that afford disabled persons the ability to improve functionality in many areas lessening their dependence on others. These devices have been referred to as assistive technology (AT) devices. “The term 'assistive technology device' means any item, piece of equipment, or product system, whether acquired commercially, modified, or customized, that is used to increase, maintain or improve the functional capabilities of individuals with disabilities” (What is Assistive Technology?, n.d., ¶ 4). AT can enhance function in a number of areas such as increased mobility, improved daily living activities, augmented communication, and expanded access to education and learning—among others. Some of these functional tasks may require computer access, which is the aspect of AT that will be the focus of this study.

Barker (2002) states that a person operating a computer must be able to achieve tasks comparable to using the mouse, operating the keyboard, understanding the display, and listening to auditory system cues. The person using the technology must be able to comprehend and react to whatever the interface happens to be. “Accordingly, access to the computer demands visual, auditory, perceptual, motor, and cognitive skills” (Barker, p.92). Persons who may need adaptations for computer access include those with the following impairments:

1) inability to use a keyboard
2) inability to use a mouse
3) tendency to suffer from repetitive strain
4) poor vision
5) damaged hearing
6) learning disability affecting reading and writing
7) impaired cognition

Adaptations may be accomplished in many ways such as keyboard modifications, mouse emulators, enhanced or simplified displays, or various software applications. However, the technology must match the individual's needs. Therefore, a comprehensive assessment of the person's function is required, particularly in the case of severe disabilities. In the relatively nascent field of AT, standards for assessment to enable computer access for persons with disabilities have not evolved into coherent and inclusive assessments of individualized needs. Thus, there is an obligation in the field of AT to design and develop reliable instruments to be used by AT professionals to determine the needs of individuals that are referred for an evaluation. This mandates that elements should be incorporated into an assessment instrument that can be used to select individually appropriate AT technology that will assist persons in improving or maintaining function in their particular environment. Proper assessments for the applications of AT devices are crucial to improving the lives of those with disabilities, thus enhancing their potential in education, work, or any other endeavor.

Problem Statement

Computers are a constantly evolving medium used by individuals in society to access information, express his or her opinion, create projects for work or school, run a business, or simply to make life easier. Many persons in our society are not the beneficiaries of technological advancements that afford greater participation in activities related to education, leisure, or work. This lack of access to computers ultimately causes people without that access to be considered as handicapped and unable to function in many social, vocational, and educational realms. Wilson (1993) reported impediments to computer access by persons with disabilities who cannot adequately use input and output devices such as operating the mouse or keyboard, inserting a disc, or seeing the computer monitor. A deficit in even one area such as mobility, vision, hearing, speech or learning can profoundly limit a person's ability to function in society. Persons with severe and multiple disabilities incur extreme losses in functionality. No matter the type or degree of disability, there are an infinite number of computer access devices available to enable access to computerized systems for persons of all ages. Unfortunately, despite the technological gains, problems continue to plague the field of AT with respect to inconsistencies and inadequacies in policies and procedures in AT prescription for those with disabilities. Derer, Polsgrove, and Rieth (1996, ¶7) state that "although encouraging advances have been made in research and practice, the fledgling field of assistive technology remains unclearly delineated." They posit that there is a dearth of information on practice guidelines and that prescribing AT devices—in their case for educational purposes—is an intrinsically difficult procedure that is prone to failure.

There are systemic problems in the emergent discipline of AT that preclude the use of proper technology for an individual's needs. Some of the factors responsible for this include improper assessment, a lack training of those involved in using the device, and nonexistent follow-up subsequent to selecting a device. The practice of AT is proceeding at a swift pace with a minimum of basic research extending beyond the product development phase (Derer, Polsgrove, and Rieth, 1996). There is a critical need for research pertaining to the assessment process in order to refine this procedure in a manner that individualizes the assessment tool, and is predicated upon the distinct needs of a particular person through a more precise determination of his/her handicaps and capabilities. This assessment may be relatively basic for those with mild disabilities, but individuals with severe disabilities may necessitate more detailed testing in order to arrive at the right choice. The assessment process needs to take into consideration the diverse impairments attendant in this population, comprised of areas such as physical, mental, emotional, sensory, and perceptual deficits. Thus, the problem of this study is the exigency to develop guidelines to judge a valid and reliable assessment of a person's functional abilities related to computer access needs that standardizes the assessment process and improves the quality of the delivery of AT to individuals with severe and multiple disabilities.

Purpose of the Study

This study will devise assessment criteria used to evaluate the validity of assessment measures for AT for computer access, specifically pertaining to the assessment of individuals with severe neurological disabilities for alternative computer access by AT practitioners. Implementing the study will entail development of a list of elements that should be included in assessment tools that can be used in home, institutional, or educational settings. The study should also assist in developing guidelines permitting computer access for persons who are prescribed AT devices based on his/her disparate needs to enable the performance of various tasks. The data will be interpreted to formulate concepts to improve the practice of AT assessment for computer access by developing categories that can be used to evaluate assessment instruments. Conceivably, this study will contribute to a body of research to assist persons in the field to develop standards and protocols that systematize the process of AT assessment for computer access. Recommendations or suggestions will be formulated for pertinent information that needs to be added to AT assessments or determine non-relevant material that can be deleted from AT assessments for computer access. This will make the assessment process a more valid measure of the needs of the individual. Further commentary on the necessity for an instrument that is comprehensive in its scope and can guide the practitioner through the assessment process in order to tailor the evaluation to the characteristics of the person being evaluated will be provided. To fulfill this imperative, it will be necessary for the AT practitioner to incorporate multiple assessment tools, or supplement existing assessments. The purpose of the study is not to fabricate a specific assessment form. Notwithstanding, I will depict what I feel are the requirements of a comprehensive and valid assessment for computer access in persons with severe neurological impairments with multiple disabilities from the criteria identified in the Delphi study.

Design of the Study

There is currently an absence of valid and reliable methods being utilized to assess individuals with disabilities for computer access in the field of AT. The literature suggests the lack of a coherent approach to the assessment process—whether in a school, rehabilitation, or other setting—when providing AT services to enable computer access for persons with disabilities. These assessments may not afford a comprehensive portrayal of the specific needs of the individual in various environments when he/she is evaluated for an AT device. The documentation of the assessment may not reflect an accurate or rigorous account of the person's functional level in his/her own environment. Finally, an AT assessment team may recommend a device that is not satisfactory with regard to the individual's needs, or is abandoned altogether.

The following questions pertaining to various aspects involved in an effective assessment instrument for computer access in persons with disabilities were addressed in the study:

1) What criteria should be established as a protocol to examine AT assessment instruments for computer access?

2) What constitutes a comprehensive assessment of a person for computer access using an AT device, especially for those individuals who have severe disabilities as a result of brain injury, based on criteria developed from a review of the current literature and a panel of experts?

These questions were addressed using a list of criteria developed by the researcher from an extensive literature review and a Delphi rating by a panel of experts that reflect the areas that should comprise a computer access assessment instrument. This was a descriptive study implemented in order to arrive at a consensus regarding assessments for computer access and the categories that should be incorporated into a comprehensive instrument. After collecting the data to generate criteria, judgments of the value of the assessment criteria in evaluating assessment instruments and recommendations for what may constitute a comprehensive assessment for future evaluation instruments were proffered. This constituted a benchmark for the Delphi survey elements that were accepted or rejected through the ratings and comments made by the expert panelists and inferences from the review of literature. Many of the research findings and pronouncements concerning the assessment process may not be validated by prior studies secondary to the relatively recent establishment of the discipline of assistive technology. No studies were found that expressly look at specific areas that should be included in instruments to assess severely disabled individuals for computer access using AT. There have been, however, a limited number of studies reported in the literature pertaining to what areas should constitute an assessment for computer access.

Quantification of the data gathered in the study was ongoing in order to identify patterns that can be used to interpret the data. An analysis for similarities or discrepancies in the data occurred in order to infer which criteria should be incorporated into an assessment for computer access. Other areas that may be identified as being deficient by the researcher were also discussed using a qualitative approach. After categorization of the data, an interpretation of the results was made using the constant comparison method. This method for qualitative analysis by Gay and Airasian, 2000 consists of defining categories and organizing data in ways that reveal trends or patterns that provide meaning to the data. Deficiencies in the assessment process were enumerated using the criteria established in the study with comments on how these problems may be rectified. However, these criteria were meant to serve as guidelines only, as no specific assessment instrument was developed.

Importance/Need of the Study

Currently, there is a paucity of standardized assessment measures for prescribing AT for computer access for persons with severe and multiple disabilities. Poor assessments frequently result in the failure of technology as an effectual tool to accommodate for or attenuate a disability. LoPresti, Koester, and McMillan (2003,¶2) expressed their viewpoint on the prevailing state of AT assessment practices stating that, “existing tools provide limited support for measuring a person’s functional abilities” and that “quantifiable measures can assist in selecting appropriate interventions, justifying interventions, and tracking the outcome of an intervention over time.” There is an obligation to administer detailed assessments in a variety of environmental contexts that are both valid and reliable measures portraying the tremendous diversity of disabled individuals and their needs. Ourland (1998) critiqued a generalized assessment form for computer access (MRCI RTS Computer Access Evaluation) revealing the lack of validity and reliability of the instrument. He concluded that many assessment tools are in need of further refinement with an emphasis on factors affecting access to computerized technology by the disabled. The inherent complexity of the needs of these persons due to congenital or acquired conditions that have produced impairments in physical, cognitive, emotional, and sensory domains makes this a daunting task. The assessment should be organized into a logical and structured instrument to facilitate decision-making in order to procure the most suitable device based on the individual’s needs.

Assumptions

Pertinent assessment criteria were formulated from a literature review and a selected panel of experts (therapists and educators) for computer access devices in the field of AT. The individual respondents to the Delphi study were knowledgeable about the field of AT, particularly computer access, and were a representative sample of individuals considered as experts in the field. The criteria developed from the literature review and a Delphi study of a panel of experts allowed for an evidence-based consensus pertaining to the areas that should be incorporated into assessment instruments for computer access using AT. The analysis will provide the means by which one may make determinations as to whether or not assessments for computer access are comprehensive and can be applied in order to reasonably appraise the needs of a person allowing for the prescription of devices that are suited to that individual. The criteria used to judge assessment instruments will be especially applicable to persons with multiple and severe handicaps secondary to neurological conditions. The data collected will provide an extant view of the emerging field of AT and assessment guidelines that should be evolving in order to take full advantage of the benefits that AT has to offer.

Limitations

A Delphi procedure may be problematic when attempting to obtain responses from selected participants due to a poor rate of return, diminishing the validity of the elements chosen as important to AT assessments for computer access. Also, there is the problem of attrition with subsequent rounds or with widespread geographic populations (Love, 1997). Procuring a representative population that will respond to the Delphi instrument throughout the iterations in which replies are solicited without an increasing rate of attrition may be difficult. The study participants may have a bias toward certain elements in the Delphi study related to his/her area of research or expertise, that may make him/her more apt to rate this category as important to the assessment process (e.g., a speech pathologist may rate communication above other areas). There may be other categories that have not been identified in the study that are important to computer access assessments, not included in the categories developed when constructing the Delphi instrument to determine criteria for an assessment. The use of categories in the study may not be focused or specific enough for developing the criteria that should constitute an assessment when attempting to elicit responses from the participants (Gay and Airasian, 2000). Explanations defining each category may not be explicit enough to be understood by the individuals participating in the survey. Wilhelm (2001) suggests that the survey developed by the researchers may influence or direct the respondents due to "preconceived notions." Likewise, the interpretation of the data by the researcher can affect the conclusions of the study depending on their own personal bias or area of expertise. Furthermore, what is a consensus? As Love (1997) explains, an absolute or true consensus is 100% agreement. However, the researcher sets the limit that is considered to be a consensus, which may vary depending upon what the researcher determines to be "substantial agreement." Love concurs that the researcher must report his/her interpretation of when a consensus is reached by stating a percentage pertaining to elements rated by the expert panel in a Delphi study.

Numerous explanations regarding why the assessment criteria that are agreed upon when the Delphi study is completed may not be valid elements that can be used to critique AT assessments for computer access may be discerned. The use of a criterion approach exclusively, may not lead to a valid measure of the efficacy of contemporary AT assessments for devices to enhance computer access. Other external variables besides the assessment technique being utilized will affect the assessment process encompassing areas such as a lack of expertise on the part of the AT team, poor follow-through after the device has been procured, insufficient staff or family training, or an absence of acceptance on the part of the individual or family. There may be difficulties in interpreting the data when attempting to establish the validity of the AT assessment process due to the diverse impairments seen in this population. There is also variability in the goals that are set for, or by particular persons with regard to tasks that are to be performed using the AT device. There is a broad range of available instruments being utilized in different settings for AT assessment, and guidelines for their use may be ambiguous. The assessment process may not be formalized in some instances limiting the ability to analyze assessment procedures for computer access. Finally, there are few methods currently available to measure outcomes in the field of AT, which causes difficultly when attempting to measure the success of a particular assessment protocol for an intervention to allow computer access (Pederson, Lange, & Griebel, 2002).

Delimitations

The criteria chosen for the Delphi study were those that are relevant to assessing impediments to computer accessibility. Data collection was restricted to assessments for computer access using AT devices, with an emphasis on the relevance to persons with neurological conditions that are severe in nature. The perceived efficacy and comprehensiveness of assessments were judged by the criteria devised through a comprehensive literature review and a Delphi study of a panel of experts. The criteria consisted of elements that affect the person's function and are linked to computer access such as posture and positioning, musculoskeletal conditions, motor control, sensory impairments, cognitive limitations, and perceptual deficits. The criteria will be used to judge assessments used in educational or clinical environments. The study is limited to data associated with assessments of computer accessibility for input, output, and software devices. I will not examine areas incorporated in other forms of AT assessments (e.g., vision, learning, hearing, environmental control, etc.) unless they are germane to the assessment for computer access. The panel of experts will be comprised of individuals who have published in scholarly journals in the field and/or are certified or credentialed as an AT practitioner by a professional organization or accredited university.

Definition of Terms

Acquired brain injury: damage to the central nervous system that occurs after birth.

Agnosia: the inability to identify objects using a particular sensory modality such as vision, although other sensory systems may still be intact.

Aphasia: when an individual is unable to communicate using speech, gestures or other means, or is unable to comprehend various modes used to transfer information due to a lesion in a particular area of the brain.

Apraxia: a deficit in the ability to execute voluntary and purposeful movement that cannot be attributed to lack of muscle force, motor control, concentration, or cognition.

Associated reaction: the involuntary motion in one area of the body such as the arm when moving another region of the body or changing positions voluntarily.

Ataxia or postural instability: impaired motor control evidenced by the inability to sustain a posture, maintain balance or equilibrium, or direct movements in a coordinated manner in the trunk, upper extremities, or lower extremities.

Attention or Awareness: the ability to focus on a particular task by an individual for a period of time.

Body scheme or postural control: a postural model of one's body, including the relationship of the body parts to each other, and the relationship of the body to the environment.

Central nervous system (CNS): brain (cerebral cortex and brainstem) and spinal cord.

Cognition: the capability to reason in order to problem-solve including the ability to organize and recall facts.

Diffuse axonal injury: brain injury that causes damage to numerous areas of the white matter of the brain in a single episode of occurrence.

Disability: limited capacity or inability to engage in roles related to employment, recreation, education or any necessary daily functions restricting opportunities to fully participate in the society in which a person lives.

Distributed or parallel processing: processing in which multiple neural networks operate in concert with one another to complete a task.

Dynamics: movement force.

Executive functions: consists of the ability to formulate a scheme to handle information in order to perform higher order cognitive functions such as the ability to reason and reflect regarding one's situation in a particular context, in order to determine the best course of action using these abstractions.

Functional limitation: the inability to perform a task on a level comparable to a person who would be considered as characteristic of the norm when assessing the manner in which the activity is conducted.

Handicap: limitation in functional capacities resulting from physical, cognitive, or emotional impairments that restrict the potential of persons to function in these areas.

Hypertonicity: increased tone in muscles resulting from upper or lower motor neuron lesions that manifests itself in a limited ability to move throughout the full range of joint excursion with difficulty in controlling movements.

Hypotonicity: diminished muscle tone due to muscle weakness or pathology of the neuromuscular system.

Impairment (direct): a decrement in the composition or performance of any system—nervous system, musculoskeletal system, integumentary system (skin), digestive system, or others—that is caused by a certain pathological process in the body and disrupts normal function.

Impairment (indirect): a secondary dysfunction in a system that is not the site of the original impairment, but is a consequence of an incipient pathological process and occurs at a later period in time.

Input device: a hardware device such as a mouse, keyboard, microphone, etc. used to enter or access data when using a computer

Involuntary movements: movements not under the volitional control of the individual that can be manifest in a number of ways.

Kinematics: movement direction

Kinesthesia: awareness of movement.

Learned helplessness: when a person remains passive or disengaged due to over-dependence on others for determining the needs of that person with a cycle of heightened subordination, feelings of inferiority, and the reliance on others.

Metacognition: awareness of one's own learning.

Motor association areas: the area of the cerebral cortex that processes incoming information regarding movement in order to execute the proper motor response.

Motor pathways: nerves that carry impulses away from the brain in order to effect a motor response.

Muscle weakness: an inability to generate normal levels of tension or force; a common manifestation of neuromuscular disease.

Ocular pursuit or gaze: the capability to track objects and maintain gaze using movements of the eyes.

Output device: the hardware components of the computer that display data such as the monitor, printer, speaker, CD ROM, etc.

Primary motor areas: the area of the cerebral cortex that is directly responsible for producing impulses resulting in muscle contractions.

Primary sensory areas: the area of the cerebral cortex that is responsible for processing direct sensory input.

Proprioception: awareness of joint or body position in space.

Sensory association areas: portion of the cerebral cortex next to the primary sensory areas that processes and integrates complex sensory stimuli so that the input can be organized in a coherent fashion to enable the stimuli to be acted upon by the individual.

Sensory pathways: pathways carrying input to the brain which interprets these messages and responds in some manner.

Severely disabled: a composite of conditions found in persons such as those with cerebral palsy or other central nervous system conditions, comprised of any number of problems related to physical, sensory, or cognitive function. The severely impaired individual may require assist with all or most of their basic activities of daily living to ensure survival, even though chronologically they should have the capacity to perform many or all of these functions independently.

Software: devices such as operating software or various programs used to perform certain functions such as word processing, Internet access, games, video, etc.

Spatial relations or visuospatial disorder: perceptual disorder in which a person is unable to discern the orientation of one's body or other objects in relation to the environment.

Synergies: stereotypical movement patterns occurring in multiple joints in concert with one another that can be considered abnormal when associated with a neurological condition disrupting normal motor control. These movements have been characterized as the return of primitive reflexes that interrupt normal movement patterns.

Traumatic brain injury: damage to the central nervous system in a child or adult due to a number of causes that transpire as the result of an accident or other impact injury to the structures of the cerebral cortex causing impaired function.

Unilateral neglect or hemineglect: the inability to distinguish sensory stimuli on one side of the body causing the person to disregard that part of the body and attend to the surrounding environment.

Visual processing disorder: the inability to process visual information from the eyes that is not a result of a problem with the eyes, but is a consequence of a lesion to the brain.

(Frederick & Saladin,1996; Haten, 2000; O'Sullivan & Schmitz, 2000; Rose & Meyer, 2002; Rosenthal, Griffith, Kreutzer & Pentland, 1999)

The following definitions of assistive technology devices and services are quoted from Public Law, 100-407(The Technology-related Assistance for Individual's with Disabilities Act, 1988).

Assistive technology: assistive technology can mean a device or service that can be used as a tool by a person with a disability to achieve or maintain function. However, you must bear in mind the consideration that Assistive Technology does not only mean a "device" but also a "service."

Assistive technology device: is defined as "any item, piece of equipment, or product system whether acquired commercially off the shelf, modified or customized, that is used to increase, maintain, or improve the functional capabilities of individuals with disabilities."

Assistive technology service: means "any service that directly assists an individual with a disability in the selection, acquisition, or use of an assistive technology device."

Organization of the Study

The study commenced with an extensive review of the pertinent literature for alternative computer access and assistive technology for persons with severe and multiple disabilities outlined in Chapter II. This encompassed literature from the disciplines of rehabilitative medicine, neuroscience, and education. A general description of the foundations of neurological anatomy and physiology associated with brain function, and the disease processes involved in brain disorders was first introduced in the literature review. Information on impairments related to severe neurological damage and the manifestations of these disorders were then portrayed. A description delineating various neurological conditions and their causes affecting persons with brain injuries was presented. The literature review concluded with background information pertaining to assessments of motor abilities and physical function in persons with neurological damage, as well as the cognitive, behavioral, sensory, and perceptual deficits associated with these impairments as this pertains to AT assessments for computer access. The review also examined assessment models that have been developed for computer access.

The literature review permitted the researcher to construct categories that should be included in an assessment instrument. This information was utilized to develop criteria to determine elements that should be included in a comprehensive assessment. The criteria were validated by a panel of experts (Speech Pathologists, Occupational Therapists, and Educators) who are certified or credentialed AT practitioners and/or persons who have published in the field. This was accomplished by utilizing a Delphi procedure to rate the importance of each of the categories to AT assessments for computer access. The methodology used in the study was described in Chapter III. The Delphi results were analyzed and interpreted using descriptive and qualitative measures and reported in Chapter IV of the study. Conclusions and recommendations based on the findings of the literature review and Delphi study appertaining to the content of AT assessment instruments were then expressed in Chapter V. The implications of the study for promoting further research in the field of AT assessments were also discussed.

CHAPTER II

LITERATURE REVIEW

The literature review consisted of a search for contemporary research and established concepts regarding the discipline of assistive technology and impairments that are observed in persons with CNS disorders related to AT prescription for computer access. This included:

- An overview of the field of AT
- Legislation relevant to AT
- Neuroanatomical descriptions of the CNS
- Sensory input in the nervous system
- Details of cognitive functions
- Theories of conscious awareness
- Details about the vestibular system
- A general description of neurological conditions
- Impairments in persons with brain injury
- Assessments of persons with CNS disorders for AT for computer access

The Emerging Discipline of Assistive Technology

Assistive Technology Overview

Charles Frame, Speech Language Pathologist, in his Keynote Address at Macomb Projects' ACTT V Conference in March 1994 depicts the history of assistive technology. He states that with regard to assistive technology, there are two separate epochs, "B.C. or

Before Computers, and A.D. or After Digital, that is, after the digital computer revolution." The vast majority of assistive technology devices at their inception, now utilized by persons with disabilities, were used for other purposes. This was usually done without the knowledge that these devices would aid persons with disabilities in the future. In 1976 the Apple Computer Corporation was formed leading the way to the development and marketing of personal computers. An Occupational Therapist used the early Apple II's with modified input devices such as adapted keyboards, mouse emulation, Morse code, and switches for clients with motor impairments. This paved the way for further innovations. Other pioneers in the field developed devices such as digital speech input and output, and synthesized speech. The military first used head tracking technology to allow fighter pilots to operate many different cockpit controls simultaneously. This technology was later adapted for use as AT in persons such as quadriplegics (Frame, 1994).

Assistive technology encompasses a broad range of devices that are described under the aforementioned definition. One area constituting AT is computer access devices. This category intermingles with other categories of AT devices to a certain extent, but is considered a distinct AT category. There are a number of types of AT that are categorized based on areas the devices are meant to accommodate. The various groupings are listed in Table 1. Many can be used for computer access, but computer access devices are always considered separately from other AT items. For example, many communication aids could be classified as devices allowing computer access such as text-to-speech software used for blind individuals. All AT devices are utilized to improve function or accommodate persons of all ages and types of disabilities. These devices can aid persons with mental or physical problems, not only enhancing function, but preventing further decline. There are AT service providers that perform assessments, develop technologies, dispense AT devices (sell or lease), or perform maintenance on AT devices (Rehabtool.com, n.d.). Generally, AT devices are separated into different products. Table 1 lists the various categories of products with a brief description of each.

Since this study focuses exclusively on AT devices for computer access, I will give examples of some of these products in order to portray their usefulness to disabled individuals. These devices can be divided into three general categories: (1) input devices, (2) output devices, and (3) software. One of the most diverse categories is input devices, with several different adaptations available such as alternative keyboards. These keyboards come with a number of features such as larger keys, different key arrangements, keyguards (to prevent missed keystrokes), and onscreen keyboards just to name a few. Another input device that has been modified is the computer mouse. This has been accomplished through a number of adaptations, a few of which are the hands-free mouse using eye or head movements, switches, or trackballs (upside down mouse with a large ball and buttons on the top). There are also a number of innovations for output devices. One is Voice Output Technology, which is a type of hardware or software that allows text on the computer to be read by a synthesized voice. Keystrokes can be read out loud as well. These devices are similar to screen readers, but are used for Internet access. Another output option is a screen magnifier that enlarges text, and can also change or invert text and background colors to enhance readability by persons with visual impairments. An example of a software application related to computer access is the word prediction program. This writing software can assist persons that have learning

Table 1: Assistive Technology Categories

Device Category	Description
Communication Aids	Speech and Augmentative Communication Aids and Writing or Typing Aids. Includes items such as communication boards, text-to-speech software, speech synthesizers, word prediction software, and Braille devices.
Computer Access Aids	Devices to enable computer access in various environments encompassing Alternative Input Devices, Alternative Output Devices, Accessible Software, and Universal Design. Includes devices such as adapted keyboards, switches, screen reading software, software accessibility features, and methods to promote universal access.
Daily Living Aids	Used to assist disabled individuals with activities of daily living such as grab bars, adaptive feeding, dressing aids, grooming devices, or bath aids.
Education and Learning Aids	Cognitive and Early Intervention Aids such as software for memory, perceptual skills, and cognitive retraining
Environmental Aids	Home or workplace accessible design products such as architectural adaptations (e.g., ramps) or Environmental Control Units to operate electronic devices such as the lights, television, or stove.
Ergonomic Equipment	Modified environments in the workplace to reduce injuries such as adapted furniture, lighting, arm/wrist supports or back supports.
Hearing and Listening Aids	Products for the Deaf and Hearing Impaired including TV amplifiers, text telephones, or hearing aids.
Mobility and Transportation Aids	Devices that allow mobility such as walkers for ambulation, wheelchairs, vehicle conversions, or wheelchair lifts.
Prosthetics and Orthotics	Devices for use when body parts are missing or are functioning abnormally such as splints, braces, or prosthetic devices.
Recreation and Leisure Aids	Products adapted for sports and leisure such as ski equipment, audio descriptions of movies, or travel aids.
Seating and Positioning Aids	Various chairs, braces, or wheelchair seating systems that are utilized to enable upright posture for function, pressure relief, or comfort.
Vision and Reading Aids	Products for those with visual impairments such as speech output devices, text magnification, talking watches, or speaker phones.

Adapted from Rehabtool.com. (n.d.). *Assistive technology links library*. Retrieved from, http://www.rehabtool.com/links.html and other disabilities by predicting what the person is typing, and using features such as speech synthesis, hotkeys (for the most used words), spell-check, and grammar prediction and usage. Other software programs are available for use by individuals with cognitive, perceptual, and motor disabilities. These software programs assist a person in organizing thoughts and planning tasks through cueing, graphics, simple menus, and a host of other features (Adaptive Technology Resource Center, n.d.; AbilityHub, n.d.).

There are numerous technological advancements that will continue to make assessments for AT a challenging and dynamic process. In her article *Focus on Special Needs (Technology Information)* Amberg (2000) illustrates technology that children in educational settings can use to navigate the Web, learn, and perform various skilled activities. There are software programs that transform the WWW into Braille or help a child guide a powered wheelchair. One specialized technology device utilizes a piezoelectric Braille display enabling accessibility to even the most intricate graphical computer screens. A hands-free device that does not use a keyboard or mouse to access parts of an Internet site by voice activation has also been developed (Amberg). Another high technology device is The Eyegaze System allowing individuals to control a computer with their eyes. This device uses keys displayed on a computer monitor accomplishing many tasks such as synthesized speech, environmental control (lights, appliances, etc.), Internet access, running software applications, and various other functions (AbilityHub,n.d.). Future advances in technology will enable persons with and without disabilities to perform tasks previously thought to be unobtainable.

With the development of advanced technology the need for enhanced assessment measures that account for both the expanded features of AT devices and the complex needs of the disabled person will become increasingly apparent. No matter how high-tech the device, if it is not used appropriately, does not enhance the function of the individual, or does not satisfy the goals outlined for its use, it is ineffectual. The assessment instruments should evolve along with new technological developments to allow for device matching. There should also be a concerted effort to exchange research and development information to ensure that AT services are updated and the assessment process adapts to the new developments in the fields of education, rehabilitation, and neuroscience.

Assistive Technology Legislation

A multitude of legislative measures have granted entitlements to the disabled. The most notable related to AT are the Rehabilitation Act of 1973 (Rehab Act), the Americans with Disabilities Act (ADA) of 1991, the Individuals with Disabilities Education Act (IDEA'97), and the Assistive Technology Act of 1998 (Tech Act) (Office of Special Education and Rehabilitative Services, n.d.). The Rehab Act was the first act to give rights to persons with disabilities and was originally utilized to authorize vocational accommodations. However, the regulations encompassed only federal job sites or any entity receiving federal funding, using the same criteria as Title I of the subsequent ADA for rulings on job discrimination. The Rehab Act of 1973 was amended most recently in 1998 subsequent to the following findings by congress:

> Congress finds that—
>
> (1) millions of Americans have one or more physical or mental disabilities and the number of Americans with such disabilities is increasing;

(2) individuals with disabilities constitute one of the most disadvantaged groups in society;

(3) disability is a natural part of the human experience and in no way diminishes the right of individuals to--

(A) live independently;

(B) enjoy self-determination;

(C) make choices;

(D) contribute to society;

(E) pursue meaningful careers; and

(F) enjoy full inclusion and integration in the economic, political, social, cultural, and educational mainstream of American society;

(Office of Special Education and Rehabilitative Services "The Rehabilitation Act Amendments of 1998",n.d.; The U.S. Equal Employment Opportunity Commission, n.d.; Reasonable Accommodations for People with Psychiatric Disabilities: An On-line Resource for Employers and Educators, n.d.)

The ADA was passed in 1991 as a broad-based legislative initiative that assures rights for persons with disabilities in all sectors of society. It was intended to proscribe acts of discrimination against persons with disabilities in employment, public accommodations, government and commercial entities, telecommunications, and transportation. The ADA characterizes impairments as mental or physical problems that impede one's ability to function in at least one "major life activity." The disabled population has suffered disadvantages with respect to employment opportunities, educational prospects, economic advancement, and cultural acceptance. The ADA is meant to enforce rules that preclude discrimination in these areas, and to draft guidelines to adapt various settings in order to accommodate the disabled. The following section of the law espouses the basic tenet of the legislation, mandating when accommodations should be made available to persons with disabilities.

> **Sec.36.303 Auxiliary aids and services.**
>
> (a) General. A public accommodation shall take those steps that may be necessary to ensure that no individual with a disability is excluded, denied services, segregated or otherwise treated differently than other individuals because of the absence of auxiliary aids and services, unless the public accommodation can demonstrate that taking those steps would fundamentally alter the nature of the goods, services, facilities, privileges, advantages, or accommodations being offered or would result in an undue burden, i.e., significant difficulty or expense.

(U.S. Department of Justice Civil Rights Division Disability Rights Section, n.d.; Text of Americans with Disabilities Act (ADA) of 1990 and The Americans with Disabilities Act Questions & Answers, n.d.; One Hundred First Congress of the United States of America, n.d.).

The most recent amendments to the IDEA were affirmed under the new designation “IDEA ’97” signed into law by President Clinton. This legislation extended the reach of the former IDEA laws and validated the right of disabled individuals to a “free and appropriate education” (FAPE). Educators utilize the Individualized Education Plan (IEP) as the principal document to ensure that proper services are rendered to enhance teaching and learning for persons with disabilities. Under IDEA’97, the IEP must consider AT under a listing of special factors that are investigated as relevant to a particular child’s needs. The following section of the law secures the right to AT for those found to have met the educational criteria necessitating the use of AT services and devices.

> **§300.308 Assistive Technology.**
>
> (a) Each public agency shall ensure that assistive technology devices or assistive technology services, or both, as those terms are defined in §300.5-300.6, are made available to a child with a disability if required as a part of the child's -
>
> (1) Special education under §300.26;
>
> (2) Related services under §300.24; or
>
> (3) Supplementary aids and services under §300.28 and §300.550(b)(2).
>
> b) On a case-by-case basis, the use of school-purchased assistive technology devices in a child's home or in other settings is required if the child's IEP team determines that the child needs access to those devices in order to receive FAPE.
>
> (Authority: 20 U.S.C. 1412(a)(12)(B)(i))
>
> (c) FINDINGS- The Congress finds the following:

> (1) Disability is a natural part of the human experience and in no way diminishes the right of individuals to participate in or contribute to society. Improving educational results for children with disabilities is an essential element of our national policy of ensuring equality of opportunity, full participation, independent living, and economic self-sufficiency for individuals with disabilities.

(Council for Exceptional Children, U.S. Department of Education, IDEA Practices, n.d.)

The Assistive Technology Act (ATA) of 1998 was ratified to sanction grants to states for the provision of assistive technology to persons with disabilities. “The ATA reaffirms the federal role to promoting access to assistive technology devices and services for individuals with disabilities” (Council for Exceptional Children, Assistive Technology Act of 1998, n.d., ¶3). Individual states are mandated to set standards and are held accountable under Title I to provide necessary services. The act acknowledges the significance of assistive technology for inclusion, independent living, education, and employment to promote “self determination.” Underutilization of assistive technology in individuals with disabilities is a persistent problem, especially for the economically disadvantaged. There is a lack of incentives that champion the use of technology, fund technology, implement laws governing the use of technology, or train persons to use technology. This is a direct corollary to the lack of collusion between the government (state and federal) and private entities to accommodate the needs of a population that demands these services. These contentions have prompted measures under Title II of the ATA to foster collaboration between government agencies (federal and state) and commercial agencies for research and design. Title III of the ATA promotes alternative funding measures to help those with disabilities obtain devices and services.

Purposes—The purposes of this Act are:

(1) to provide financial assistance to States to undertake activities that assist each State in maintaining and strengthening a permanent comprehensive statewide program of technology-related assistance, for individuals with disabilities of all ages, that is designed to--

(A) increase the availability of, funding for, access to, and provision of, assistive technology devices and assistive technology services;

(B) increase the active involvement of individuals with disabilities and their family members, guardians, advocates, and authorized representatives, in the maintenance, improvement, and evaluation of such a program;

(C) increase the involvement of individuals with disabilities and, if appropriate, their family members, guardians, advocates, and authorized representatives, in decisions related to the provision of assistive technology devices and assistive technology services;

(D) increase the provision of outreach to underrepresented populations and rural populations, to enable the two populations to enjoy the benefits of activities carried out under this Act to the same extent as other populations;

(E) increase and promote coordination among State agencies, between State and local agencies, among local agencies, and between State and local agencies and private entities (such as managed care providers), that are involved or are eligible to be involved in carrying out activities under this Act;

(F) (i) increase the awareness of laws, regulations, policies, practices, procedures, and organizational structures, that facilitate the availability or provision of assistive technology devices and assistive technology services; and

(ii) facilitate the change of laws, regulations, policies, practices, procedures, and organizational structures, to obtain increased availability or provision of assistive technology devices and assistive technology services;

(G) increase the probability that individuals with disabilities of all ages will, to the extent appropriate, be able to secure and maintain possession of assistive technology devices as such individuals make the transition between services offered by human service agencies or between settings of daily living (for example, between home and work);

(H) enhance the skills and competencies of individuals involved in providing assistive technology devices and assistive technology services;

(I) increase awareness and knowledge of the benefits of assistive technology devices and assistive technology services among targeted individuals;

(J) increase the awareness of the needs of individuals with disabilities of all ages for assistive technology devices and for assistive technology services; and

(K) increase the capacity of public agencies and private entities to provide and pay for assistive technology devices and assistive technology services on a statewide basis for individuals with disabilities of all ages;

(2) to identify Federal policies that facilitate payment for assistive technology devices and assistive technology services, to identify those Federal policies that impede such payment, and to eliminate inappropriate barriers to such payment; and

(3) to enhance the ability of the Federal Government to--

(A) provide States with financial assistance that supports—

(i) information and public awareness programs relating to the provision of assistive technology devices and assistive technology services;

(ii) improved interagency and public-private coordination, especially through new and improved policies, that result in increased availability of assistive technology devices and assistive technology services; and

(iii) technical assistance and training in the provision or use of assistive technology devices and assistive technology services; and

(B) fund national, regional, State, and local targeted initiatives that promote understanding of and access to assistive technology devices and assistive technology services for targeted individuals.

(One Hundred Fifth Congress of the United States of America, Public Law 105-394 105th Congress, Council for Exceptional Children, n.d.)

The Nervous System Structure Related to Assessment for Assistive Technology for Computer Access

A working knowledge of neuroanatomy and neurophysiology related to cognition, motor control, and sensory function is vital to understanding the AT needs of persons with severe neurological disorders or any other disabling condition that may restrict computer access. Determining the impact of disabilities that emanate from impairments affecting the nervous system is requisite for assessing the functional needs of persons with neurological conditions that may be ameliorated through enabling computer access. Frequently, the child or adult may have incurred deficits that are a culmination of damage to a number of areas in the nervous system concurrently, producing severe and multiple disabilities. Parsing out the multitude of deficits that may afflict a person due to extensive damage to the neurological system can be a prodigious undertaking. The nervous system is exceedingly complex, and the ability to successfully execute movements and complete tasks is dependent upon the coordination and integration of diverse elements that comprise the central and peripheral nervous systems. Whereas specific structures in the nervous system may have an explicit function, complex tasks necessitate the synchronization of varied entities within and between regions that often have overlapping roles.

A concept in contemporary neuroscience that models functioning of the brain is expressed as *distributed* or *parallel processing* in which multiple neural networks operate in concert with one another to complete a task. In the book Teaching Every Student in the Digital Age, Rose and Meyer (2002) illustrate how learning transpires in an individual using several mechanisms in the brain concomitantly. They divide the process of learning into recognition, strategic, and affective components. For example, when writing a letter, initially recognition of the objects associated with the task must occur, strategies for manipulating the pen and paper must be contemplated, and subsequent affective components that encompass thoughts and emotions must be dealt with. These divisions within the structure of the brain permit considerable flexibility and variability when performing a multitude of tasks. As a consequence, persons can go about their daily lives and learn novel tasks using extraordinarily diversified modes for conceptualizing different approaches to learning. This not only applies to thinking tasks, but also motor tasks as well. For example, to voluntarily execute a movement an individual must be attentive to exigencies—both internal and external—at a particular moment in time. The individual can then achieve a plan for movement (consciously or unconsciously), and initiate the movement using the neural connections to the muscles from the brain and spinal cord (Frederick & Saladin, 1996).

Nervous System Structure

The nervous system is an intricate array of pathways consisting of neurons that are the smallest working unit in the nervous system. The neurons are comprised of the cell bodies, branches for input called dendrites, and processes extending from the cell body for output called axons (Figure 1). The substance that binds the neurons together is referred to as the glial substance. The nervous system consists of 1 trillion neurons and 10 trillion neuronal connections. The cell bodies are distinguished as the gray matter on the outer surface of the brain and spinal cord, while the axons and their connections are designated as white matter. In spite of its complexity, the brain can be perceived as having two major tasks: to monitor and control the internal and external environments that a person inhabits (Rose & Meyer, 2002; Newfoundland Brain Injury Association, n.d.).

Anatomically, the nervous system is partitioned into the central nervous system (CNS) (Figure 2) consisting of the cerebral cortex (including the basal ganglia [not pictured] and cerebellum), the brainstem, and the spinal cord; and the peripheral nervous system (PNS) encompassing the peripheral and cranial nerves. Functionally, the nervous system is demarcated into the somatic portion that regulates the motor, cognitive, and sensory activities of the individual; and the visceral or autonomic division controlling the organs. Electrical transmission between neurons occurs in both directions, with input and output to and from the CNS, and within the CNS (Noback & Demarest, 1986; Wise & Shadmehr, 2002). For the purposes of this discussion of severe neurological insults

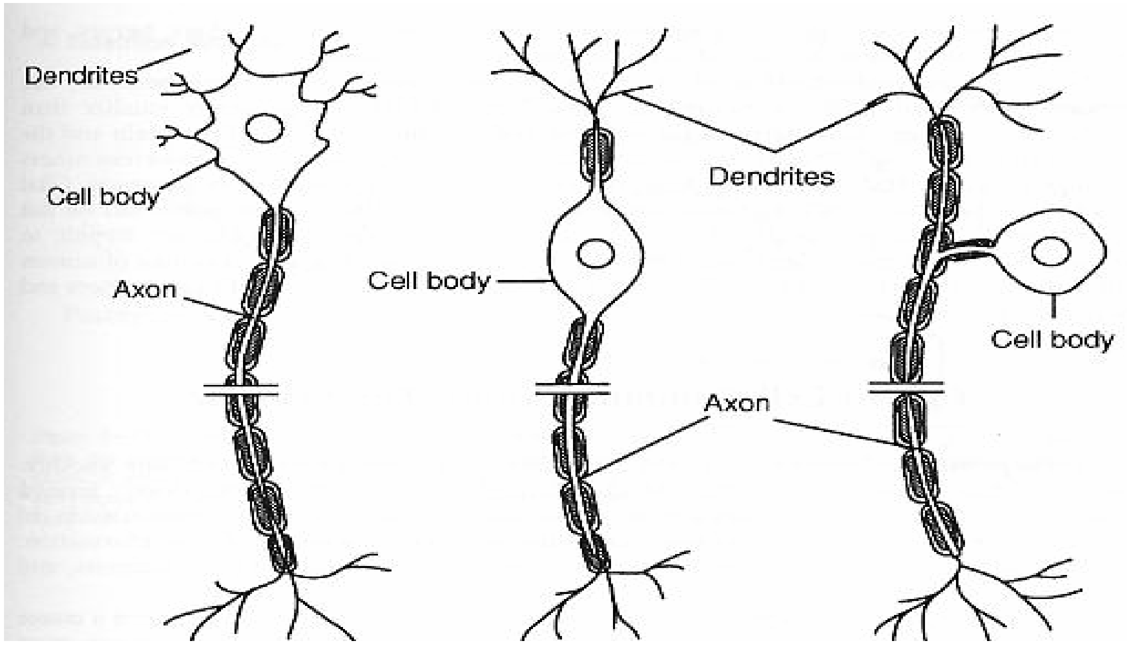

Figure 1: Neuronal Structure

Neurons are comprised of the axon, cell body, and dendrite.

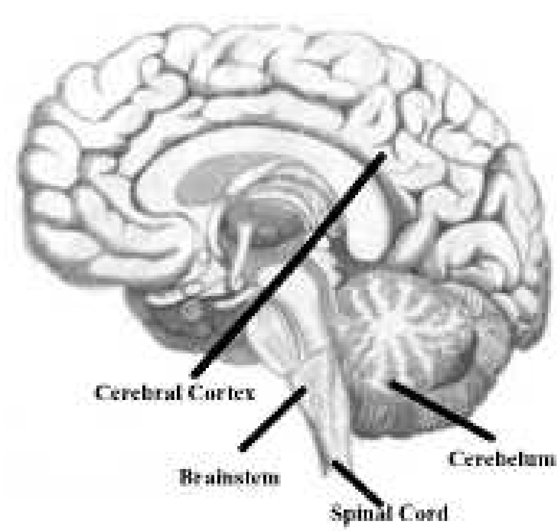

Figure 2: Central Nervous System

causing multiple disabilities, the preponderance of the anatomical and physiological. descriptions will be limited to the brain, cerebral cortex, and brainstem.

The sensory pathways are composed of a myriad of receptors that convey information to the CNS (Figure 3). The pathways consist of the 12 cranial nerves controlling vision, olfaction, equilibrium, hearing, and sensation of the mouth, head, and tongue. The cranial nerve pathways are connected to the brainstem—with the exception of the olfactory and the optic tracts. Another component of the sensory nerve pathways are the peripheral nerves, ascending in the spinal cord using two major trajectories. The first major peripheral nerve pathway, the dorsal column, transmits sensory input such as vibration, touch, and two-point discrimination from specialized nerve endings in the skin. It also delivers proprioceptive (movement awareness) feedback from receptors in the muscles and joints to the sensory cortex. The second peripheral pathway is the spinothalamic tract that transmits pain and temperature sensations to the sensory cortex. (Chusid, 1985; Federicks & Saladin, 1996; Hollinshead & Rosse, 1985; Noback & Demerest, 1986; Stokes, 1998). In addition to these pathways, there are specialized sensory organs in the muscles and tendons known as the muscle spindles and golgi tendon organs that detect shortening or lengthening of the muscles and tendons by sending input to the cortex to regulate muscle tone. (Chusid, 1985; Federicks & Saladin, 1996; Noback & Demerest, 1986).

All of the sense organs relay information to processing centers located in the laminae (levels) of the spinal cord and the brain, with most of the pathways crossing over to send impulses to the opposite side of the brain (Chusid, 1985; Federicks & Saladin, 1996; Noback & Demerest, 1986; Stokes, 1998). Conversely, there are two descending

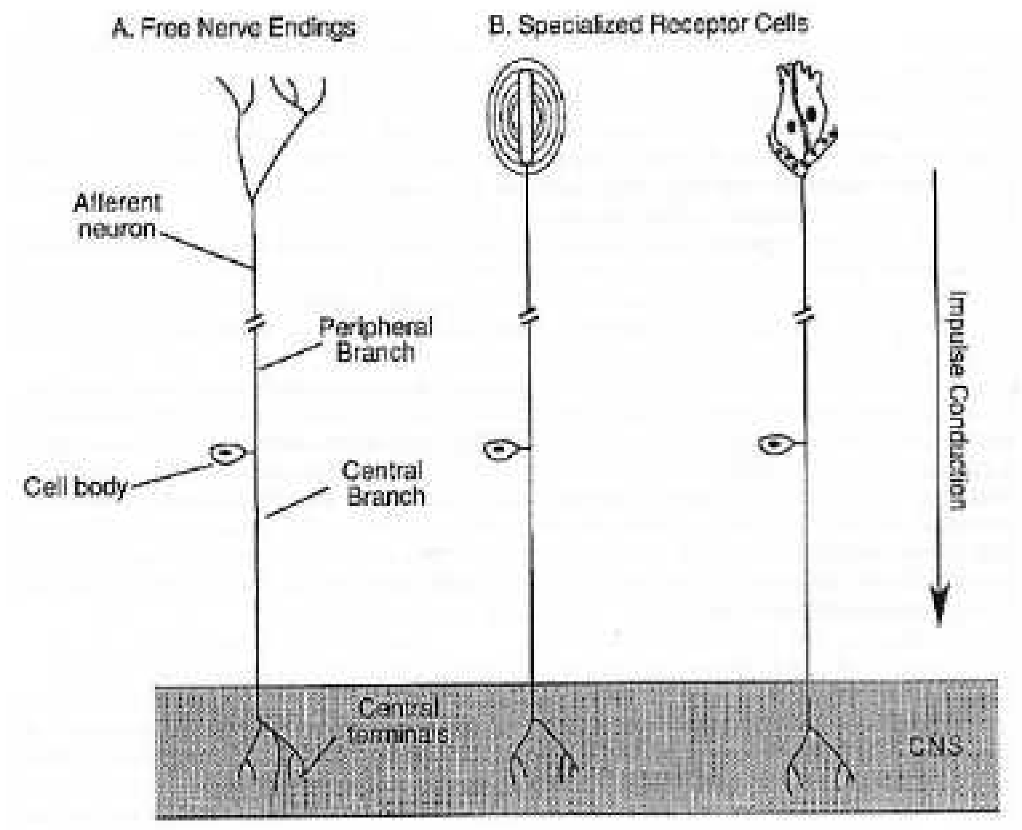

Figure 3: Sensory Receptor Cells

Free nerve endings (left) and specialized nerve cells (right) that transmit sensory information such as pain, vibration, light touch, temperature, and proprioception to the CNS.

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neural trajectories from the cortex. Projections from the spinal cord that innervate the muscles are known collectively as the pyramidal or corticospinal tracts. The other grouping of nerve pathways is composed of descending tracts (also some ascending) from the cerebellum and basal ganglia that regulate muscle tone, coordination, and posture—the extrapyramidal tracts. (Chusid, 1985; Federicks & Saladin, 1996; Noback & Demerest, 1986; Stokes, 1998; Wise & Shadmehr, 2002).

Cerebral Cortex

The cerebral cortex of the brain consists of 5 lobes: the frontal, parietal, occipital, temporal, and limbic. Each lobe has 3 functional divisions: (1) primary-deals with basic functions such as sensory input or muscle contraction, (2) secondary-interpretive center for basic neural impulses (e.g., perceptual awareness or muscle coordination), and (3) tertiary-integration and processing of the lower level functions (e.g., motor planning or cognition) (Newfoundland Brain Injury Association, n.d.). The associative areas of the brain execute higher level, abstract mental functions such as interpreting sensory input and cognitive functions for reasoning and decision making. Generally, through the interface of input and output signals in the nervous system, and the integration of neuronal impulses in the CNS and PNS, we are able to regulate cognitive, sensory, and motor activities in order to carry out daily tasks (Chusid, 1985; Federicks & Saladin, 1996; Noback & Demerest, 1986; Stokes, 1998; Wise & Shadmehr, 2002).

The regions of the brain are numbered (Brodmann's areas) within each lobe of the brain (Figure 4). Portions of the frontal lobe are area 4 (motor area), area 6 (premotor area), and areas 9, 10, 11, and 12 (frontal associative areas) that initiate and control movements and thought processes. Part of the parietal lobe contains areas 3, 1, and 2 that

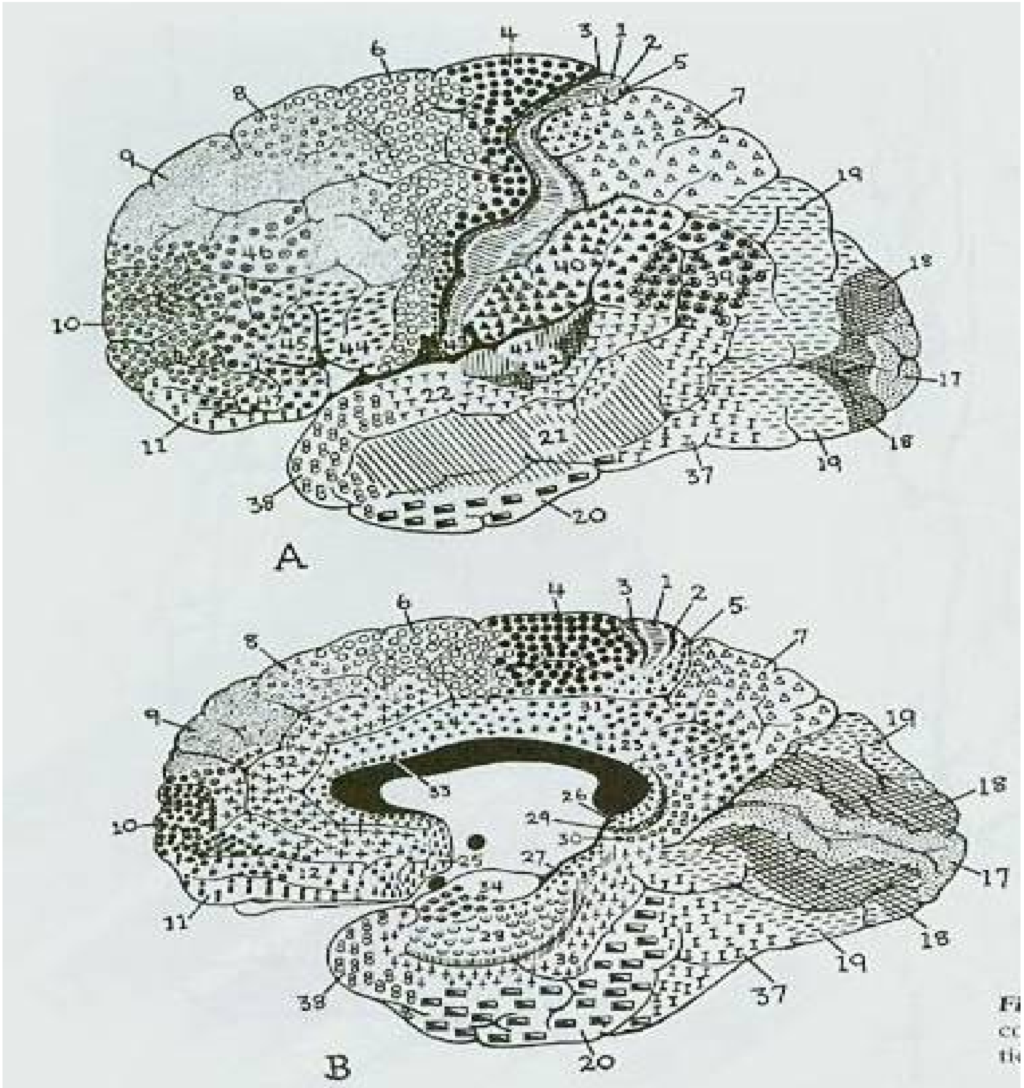

Figure 4: Brodmann's Areas

Different regions of the brain are numbered based on the function of individual groups of cells (cytoarchitectural organization).

From *Pathophysiology of the Motor Systems* (p. 166), by C. M. Frederick, and L.K. Saladin, 1996, Philadelphia, PA.: F.A. Davis Company. Copyright 1996 by F.A. Davis Company. Reprinted with permission.

decode sensory input. A component of the temporal lobe consists of the auditory (area 41) and associative cortex (area 42) for hearing and interpreting sound. A section of the occipital lobe contains Brodmann's areas 17, 18, and 19 for processing visual input. The limbic lobe (rhinencephalon) is the primary visceral cortex for functions such as memory and emotion.

The sensory homunculus and motor homunculus (Figure 5) symbolize the various body regions superimposed upon the brain. Figure 5 depicts the cortical representation schematically by sketching the various body regions and inserting them onto the brain surface from the medial (inside) to the lateral (outside) region of each hemisphere. The figure illustrates topographically the extent of innervation of one area of the body in proportion to others. Note the disproportionate representation of the hands and the face. This is due to the extraordinarily intricate sensory and motor processes required for sensation and movement in these regions.

Technology for electrophysiological mapping of the sensory and motor areas has evolved, enabling a more detailed representation of anatomical structures. Yet, there is no consensus regarding the number of areas that carry out motor and sensory functions. There may be as many as 10 motor, and 30 sensory areas according to Das et al. (2001). However, there is a measure of plasticity inherent in the nervous system of adults and children that instigates changes in neuronal patterns that represent different structures, suggesting that the brain is not hardwired, but malleable (Das et al., 2001). An exemplar of the plasticity of the nervous system would be a neural network such as the motor system. Imaging studies have confirmed that the motor system is comprised of interconnected brain regions.

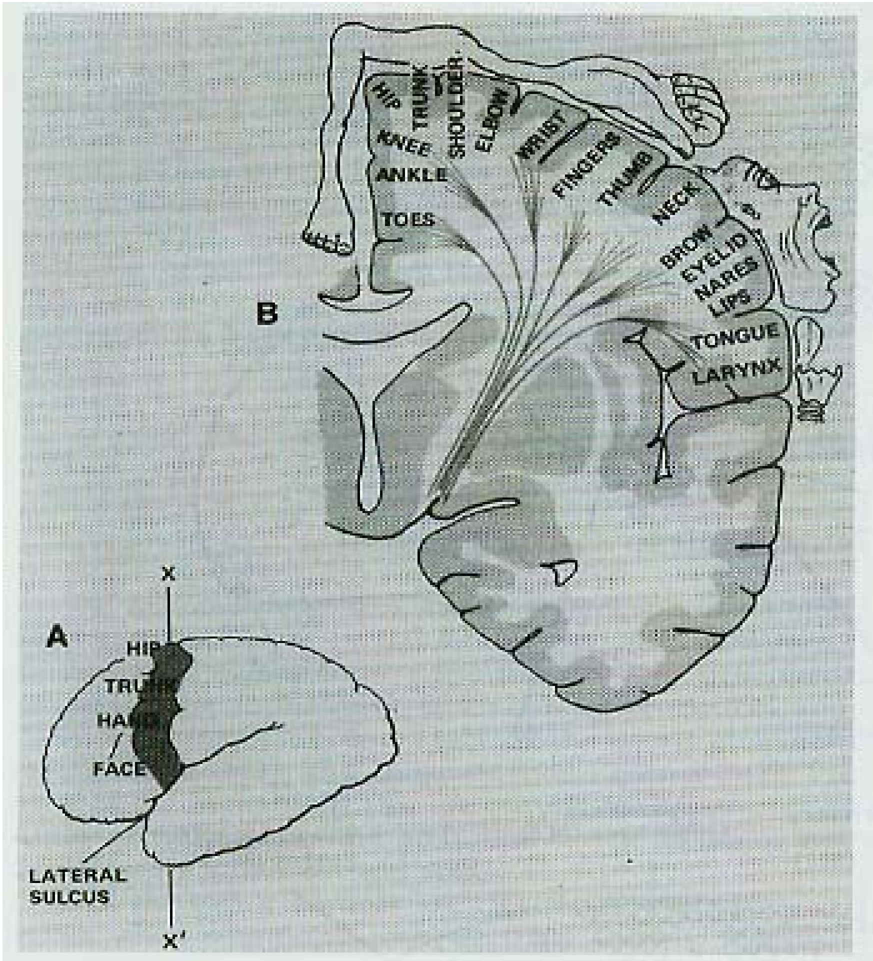

Figure 5: Sensory and Motor Homunculi

The sensory and motor homunculi depict the area of the cortex allotted to each body region for sensory input and motor function. Each body area is superimposed on the outside of a cut section (frontal view) of the cortex at the motor (frontal) lobe and sensory (parietal) lobe.

From *Essentials of Clinical Neuroanatomy and Neurophysiology* (p. 183), by S. Gilman, S.W. Newman, 2003, Philadelphia, PA.: F.A. Davis Company. Copyright 2003 by F.A. Davis Company. Reprinted with permission.

Motor Control

According to Wise and Shadmehr (2002) the ability to run, walk, and talk in vertebrates developed approximately 500 million years ago as a progression from a pre-existing means for locomotion such as flying, galloping, or burrowing. Since then movement in organisms has evolved to more sophisticated levels in order to adapt to the needs of humans, an indication of the inherent plasticity of the nervous system. The CNS accomplishes movements in the many joints and muscles of the human body. The CNS also coordinates movement using the visual, somatosensory, and vestibular systems in varied contexts, in conjunction with association regions in the brain to plan movements.

"The human motor system controls goal-directed movement by selecting the targets of action, generating a motor plan, and coordinating the forces needed to achieve these objectives" (Wise and Shadmehr, ¶1, 2002). Persons store motor engrams (patterns) in the cortex to utilize in disparate environments and situations. Many of these motor acts are believed to be unconscious. Central Pattern Generators (CPGS) in the spinal cord and brainstem (cranial nerves) control many of the automatic movements of the extremities, face, tongue, and eyes based on sensory input. Movement is reliant on vision and proprioception to position the limb segments (inverse kinematics). Additionally, inverse dynamics refers to the process by which elements in the nervous system are used to estimate the torque needed for a particular motion (Wise & Shadmehr).

Motor control occurs at various levels in the nervous system, in the spinal cord, brainstem, and cortical regions. The highest level of motor control is often thought to be the cerebral cortex, in which the most complex voluntary movements may transpire. "The execution of voluntary movement requires an ongoing awareness of the internal and external environment, a motor plan or strategy, and axonal connections through which the cerebral cortex can exert its influence on the musculoskeletal apparatus" (Federicks & Saladin, 1996, p.158). Depending on which anatomical structures are engaged, the cortex receives sensory input and transports these inputs to the frontal lobe. The premotor and prefrontal regions of the frontal lobe deliver the information to the primary motor cortex where multiple descending pathways from the primary motor and premotor areas connect directly or indirectly to the motor endplates that innervate the peripheral muscles. At a microscopic level movement occurs due to the biomechanical and chemical properties of the tissue that enable the muscle to contract after the release of the neurotramsmitter (acetlycholine) from the nerve ending (motor endplate) connected to the muscle. A muscle contraction is caused by proteins in the muscle that bind to each other (myosin and actin filaments). Histologically, there are two types of muscle fibers, extrafusal that produce movement and intrafusal that provide sensory feedback on muscle length or stretch (Wise & Shadmehr, 2002).

Coordinating complex and precise movements also incorporates contributions from the cerebellum and the deep structures in the brain known as the basal ganglia. The cerebellum receives a significant amount of input from the visual, vestibular, and auditory systems, and has connections to the motor regions. In addition, it is thought to have a role in the planning and timing of movements for muscle activation and the maintenance of equilibrium and posture (Federicks & Saladin, 1996). The basal ganglia are a set of nuclei deep in the cerebral hemispheres composed of the caudate nucleus, putamen, globus pallidus, substantia niagra, and subthalamic nucleus. The basal ganglia operate in accordance with the concept of parallel processing—which was described earlier as distributing function toneurons throughout the cortical regions—initiating movements and also contributing to cognition and visual pattern recognition (Federicks & Saladin, 1996).

Motor Control Theories

There are various theories of normal motor control that have been proposed in the literature. Some of these theories hypothesize that all types of motions are merely a series of reflexive movements, while other researchers believe that movement is more complex and refined. Scientists in the field speculate that movement occurs in a hierarchical system in which the cortex regulates reflexive movements at all levels, while others envision a nervous system that apportions the control of movement throughout the brain, and the dynamics of a movement are established relative to the context in which it occurs (i.e., the requirements or demands placed upon the person at a particular point in time). (Bradley, 2002; Federicks & Saladin, 1996)

Seitz (1993) wrote that brain networks for movement and cognition are intimately coupled to one another; therefore, we plainly have a "thinking (and feeling) body." Seitz proposes that individuals use their bodies to think “kinetically” and that thoughts and movements are extensively intertwined. Seitz cites an example of a person using gestures or movements when talking or during other cognitive activities such as looking for a lost object. When children are very young they communicate through gestures (e.g., they point to things they want or they reach out when they want to be carried). As children become older they display expressions of pain, or they may use hand movements such as a wave to communicate. These examples illustrate the impact that motor activities have on conveying our own distinct behavior with regard to how we communicate it to others. From the perspective of Seitz, the body develops distinct movement patterns through practice (e.g., a professional ballet dancer).

Jeannerod (2002) discusses the assumption that motor planning is based on alleged schemas of movements encoded in the brain. Jeannerod endeavors to differentiate between automatic and voluntary movements, where schemas are the most elemental form of movement used to accomplish more complex, purposeful movements. The principle uncertainty espoused regarding this premise is how, or when, do we convert from automaticity of movements to conscious awareness when executing a task. Jeannerod characterizes various regions of the brain that promote awareness of movement such as the prefrontal region. Jeannerod also distinguishes between different levels of awareness. For instance, when we reach for an object, we know that we are reaching, but we are not consciously aware of this during the movement. For many movements it is more efficient and adaptive not to have to consciously think about a movement (e.g., avoiding some sort of imminent danger by jumping out of the way). Jeannerod advances the concept of neural networks that are arranged hierarchically—in lieu of schemas—to explain the transition or evolution of movement awareness from unconsciousness to consciousness. Intention plays a decisive role in allowing a person to determine the goal of the movement being performed in a certain context. Likewise, an individual may be conscious of a movement after-the-fact, such as in certain social situations. In addition, Jeannerod (1994 abstract) speaks to an apparent association between motor imagery and motor preparation. This is evidenced by the utilization of the same neural structures when performing these activities. This mental imagery is transferred into motor "schemata" that are used in preparation for the movement for a chosen goal, with activation of the posterior parietal or premotor regions of the cortex.

The supposition that some movements are subconscious is exemplified by the vestibular ocular reflex (VOR) (movements of the eyes to keep images stable during movements) and the stretch reflex (brief muscle contraction elicited by tapping the muscle tendon). These movements are implicit because they are not under voluntary control. Explicit or voluntary actions can become implicit or automatic after they have become routine after repeated performance. The motor system can also develop an internal model for generating precise voluntary actions by using specific muscle synergies that are the most effective or efficient, and "consolidating" these into the motor memory. The plasticity of the nervous system helps one to develop and realize new capabilities incorporating these newly acquired skills as more automatic or routine abilities.

The brain is recognized as a dynamic structure in all aspects of function, including sensory, motor, and cognitive elements. These components of function are distributed throughout the brain, and rely on feedforward and feedback mechanisms to respond to stimuli with remodeling of neural pathways to form new connections. There is also a certain amount of overlap and redundancy of functions between the different systems or networks. (Das, 2001; Wise & Shadmehr, 2002). Churchland and Sejnowski (1988) explore different levels of processing in the nervous system from molecules to synapses, neurons, networks, layers, maps, and systems extending from the peripheral division of the nervous system to higher cortical regions. Notwithstanding, this configuration depicting a hierarchal system is not indicative of how the nervous system truly operates based on contemporary theories. As was noted before, the neurological system functions utilizing parallel and distributed processing—both feedforword and feedback—in the cortical regions. Churchland and Sejnowski conceive of a more “democratic” organization and processing of neural input and output by well established, interacting networks. They delve into the organization of the brain and how this impacts neuroprocessing in different areas of the cortex from visual function to reasoning capabilities. Realizing the functional allocations of the various regions of the cortex is a prerequisite to understanding how distributive networks interact with one another in order to manage the Byzantine nature of the elaborate circuitry in our central nervous system.

Components of Motor Control

There are numerous theories presented in the literature for how the brain coordinates movement in humans. At this time there is not one accepted theory of the neurophysiological basis for motor control. However, as the movement sciences have utilized technological advances such as imaging techniques, areas of the brain involved in motor control are beginning to be mapped according to their various roles in producing and coordinating movement. This section summarizes some of the extant literature pertaining to motor function.

The movement that has been studied most often is reaching; however, much of the data on this movement task can be extrapolated to motor control in general. Gribble & Scott (2002) demonstrate that motions are not merely straight line trajectories from point A to B, but that the nervous system “has knowledge of its own dynamics and the dynamics of external loads.” Furthermore, the nervous system is continuously fine-tuning movements based on internal and external factors. Robertson (2000) investigated the neurological underpinnings of reach and grasp. His data established evidence verifying anatomically distinct regions of neurons that code for different movements. However, he emphasized that there is "interdependence" between the various neural networks that are responsible for vision and motor control. The disparate groups of muscles work in concert with each other (synergy patterns). A case in point is the postural muscles of the trunk and the limb that are innervated by separate descending nerve pathways, but may work collectively depending on the movement. Haggard (2001) studied motor programs which are internal models for motor learning. Simple goals require detailed planning for movements. Humans also use proprioceptive or other sensory input to alter movement patterns depending on the context in which the motion transpires.

The posterior parietal area presupposes goal directed movement with input from the parietal-occipital area utilizing visual feedback (retinal response) to manage gaze, and eye-hand coordination. These sensory areas in the cortex send information that is encoded in the premotor area of the cortex (Wise & Shadmehr, 2002). Primary motor areas manage arm trajectory, and the premotor cortex is concerned with visual targeting of the movement. Vision has been portrayed as an adjunct to movement, (i.e.,visual processing is necessary for the initiation of movements and vital for directing movements as they occur) (Binstead, 1999; Wise & Shadmehr, 2000). Visual processing can be expressed in two modes of operation; retinal (tracking a stimulus and spatial perception) and extraretinal (afferent input from the motor system and proprioceptive system). Binstead depicts the oculomanual system as a mechanism combining vision and motor tasks to establish an interface between the motor and ocular smooth pursuit systems, utilizing feedback and feedforward paradigms to control movements. In two separate experiments he determined that retinal and extraretinal information were important in "aiming movements." Preprogramming of movements and alterations during movements using retinal and extraretinal networks were both determined to have an impact on governing movements. In spite of these findings, the exact mechanism for eye-hand coordination is not precisely known.

Gaze shift—the ability to direct attention and focus gaze back and forth between persons and objects—has implications for attention and learning in children. It has been inferred that not only motor, but perceptual and cognitive factors are involved in the impairment of gaze shift in children with disabilities, and that these children institute significantly less gaze shifts. Gaze shifts increase in complexity with motor development. Neurons in the cerebellum related to vision during movement have been proven to "code" for movements in a visual framework that is temporally mediated based on outputs from the motor system. This represents a feedforward mechanism that evaluates the sensory outcome during visually guided movements of the arm and prefigures the movement of the arm before any actual motion transpires (Bartels, Cress & Marvin, n.d.; Liu, Robertson, & Miall, 2003).

Haggard (1996) studied spatial patterns used in upper extremity movements, recognizing that prior research has demonstrated that movement is embodied in "motor control schemes." Haggard employed a "multivariate" experimental methodology (Procrustus analysis) in order to probe both intrinsic and extrinsic factors during pointing movements. Haggard detected situations in which inverse kinematics were used, meaning that when a person performs multi-joint reaching tasks, the nervous system automatically chooses the best pattern of movement. Haggard was unable to determine conclusively whether the brain manages kinematics (movement direction), dynamics (movement force), or both. Notwithstanding, multi-joint movements are thought to require both complex kinematics and dynamics that seldom produce a straight line path. Haggard found substantial variability in both intrinsic and extrinsic factors controlling movement, primarily when positioning the extremity at the end of the movement. The motor system prefers straight reaching movements (straight hand paths) even if joint rotation must occur, but this is often difficult to execute due to the variability in the contexts in which movements occur. The system perceives ease of movement as the most salient factor in considering how a movement will be executed.

Sensory Input Related to Motor Function to Use Technology

Coordinated arm movements in humans necessitate a precise infusion of impulses from diverse senses including auditory, visual, and somatosensory inputs. It is incumbent upon the system to integrate these senses in a "dynamic" manner to enable repetitive, goal directed movements. How is sensory input from vision and proprioception transferred to limb movements? The primary visual cortex system is highly plastic with modular features, permitting the capability to shift neural representations contingent upon patterns of activation. Visual information is programmed into the system after receiving input regarding the position of the body including the head, and the position of the limb prior to movement initiation. Parietal neurons preprogram visual targets in a body-centered space subsequent to receiving information on head orientation. Sensorimotor input allows eye movement to precede hand movement. This improves the precision of both visual and motor movements utilizing the same somatosensory information. Tactile surfaces also exhibit adaptive features with additional cortical representation of areas that are more frequently activated (see Sensory Homunculus, Figure 4) (Kaas & Collins, 2001; Neggers and Bekkering, 1999). Neggers and Bekkering (2001) examined how saccades (quick eye movements to a target) and hand movements interact during reaching tasks. They depict a scenario where the eyes focus (foveate) prior to initiation of a movement to an intended target, and how the motion is less accurate if the individual is unable to foveate. The saccacdes evoke "gaze anchoring" in which the CNS induces the saccades to persist in the same direction as a movement pending its completion. Looking away (saccades directed away from a movement target) was extremely difficult to bring about in subjects during the movement. Moreover, if visual tracking was successfully excluded from involvement in the movement, an alternate internal mechanism such as proprioception was integrated by the oculomotor system. This provides substantiation for some means that forces the line of gaze to shift to the intended target, and confers supporting evidence to the theory that spatial attention and goal directed movements are obligatorily coupled.

The parietal system represents images of movements and classifies external movements. If there is a lesion, this change confuses the sensory system which may engender sensory neglect. The neural correlates of the spatial sensory system in relation to the motor system have been explored by researchers. The primary motor cortex is not the only direct connection to the muscles via the corticospinal tracts. The premotor areas are also linked to the corticospinal tracts. The premotor areas have a privileged role in muscle activation, and also engage in sensory or associative processing of visuospatial information. Movements can be limb dependent or target dependent, contingent upon which neurons are regulating the movement. There appear to be certain aspects of a movement during which the sensory component of cells in the motor cortex detect the context in which the movement is to take place, especially when initiating a movement. Subsequent to the sensory processing by these cells, there is a sensory to motor transformation (e.g., spatial sensory to motor transformation) (Blakemore & Frith, 2003; Shen & Alexander, 1997). It has been hypothesized that spatial attention is simply a preparatory endeavor for a motor act that may not even occur. As was stated previously, preferred patterns of movement are termed synergies that are components of most motor actions. Tseng (2003) commented on how these synergies may confer additional flexibility or options for movement trajectories. Tseng uses principal component analysis to characterize movements that are performed over a certain period of time. The redundant patterns that constitute movement synergies that are available in the nervous system appear to be utilized in order to institute the most efficient movement pattern for a particular task. This inhibits the use of nonessential or superfluous synergy patterns. In conditions testing for various tasks in goal and non-goal related reaching, one preferred synergy tends to underlie most movements. Persons tend to favor hand movement patterns generating more precise movements of the dominant hand—whether it is the left or right. Activating the same hemisphere of the brain for vision and reaching concurrently generates the fastest movement time. Moreover, attention is directed to the same side, as evidenced by the orientation of the head. Sensorimotor integration denotes the manner by which the CNS acquires information using sensory feedback to relay the context in which a movement is to take place. Motor commands rely on updated contextual information. The CNS determines the context of a movement using two types of internal model brain processes—context evolving and sensory feedback. Internal models predict sensory consequences, anticipate different contexts, and capture the manner in which contexts change over time. Sensory feedback provides information on external factors. An individual must combine these two inputs in order to achieve precise motor control (Tseng, 2003; Vetter & Wolpert, 2000).

Auditory input is another perceptual element that is important for normal functioning. The physiological underpinnings of sound reception and especially processing of sounds are described in an article by Naaten and Winkler (1999). After a sound is transmitted by the 8^{th} cranial nerve to the auditory cortices, there is a point at which this input is represented in the neural network, the sound is perceived, and it enters the memory. As the neurons are activated a sound must become encoded in a manner that allows the higher centers to interpret the stimulus. Inputs that are encoded are representational, and the inputs are categorized as pre-representational before they are encoded. A "unitary stimulus event" can be mapped in the auditory area to ascertain which sounds are relevant. This can be altered when the processing of sounds is faulty and the individual lacks the ability to distinguish sounds or if his/her hearing is impaired.

Cognition Related to Computer Access

Merlin Donald (2001) in <u>A Mind So Rare</u> presents a scientific discourse on levels of awareness, and how the brain has evolved to a level in humans that permits them to perform executive functions. He details three levels of consciousness: (1) basic perceptual unity or binding that we share with other animals, (2) short term working memory that recognizes the existence of a binding mechanism to be developed over time, and (3) "intermediate term governance" which denotes metacognition adding a conscious processing component to working memory. Cognition is an important component of voluntary motor planning (i.e., voluntary movements to access a computer for school, work, or leisure). Brain imaging techniques have lead to revolutionary advancements in cognitive neuroscience in an attempt to localize the area of the brain responsible for cognitive functions. Sarter, Bernston, and Cacioppo (1996) debate the capacity to localize cognitive functions by imaging techniques. Localization of function is complicated by the multivariate nature of cognition that involves sensory and perceptual inputs, learning, and memory; all components necessary to the intricate process of reasoning. Pending enhancements in methods of detecting brain function at the neuronal level, the validity of scanning techniques to explain cognitive functioning remains questionable in the opinion of Sarter and his cohorts. “Even for functions that are localized to specific neural circuits, these circuits may (a) be diffusely organized or widely distributed; (b) anatomically overlap, or even share common neuronal elements with circuits mediating different functions; or (c) perform different functions depending on the patterns of input—activation associated with different cognitive states or contexts” (Sarter, Bernston, & Cacioppo, ¶ 12). The operative word in this statement is context, requiring sophisticated responses in the realm of cognition.

Eakin (2003) analyzed cognition from the perspective of mind-body interaction. The famous 15th century philosopher DeCartes argued for the dualist theory of the mind as a “reasoning machine” which is completely detached from the body. Another 15th century philosopher, Spinoza, contradicts this view, accentuating the fact that the mind and the body coexist. Spinoza proposed that the mind and body are interconnected, and that the body’s subsistence is intrinsically dependent upon the mind. The brain is connected to the consciousness, and is used in emotions that are connected to everyday life and survival. Eakin examined impaired affect, resulting in poor decisions –signifying the ability or inability to carry out basic life skills. Eakin's article buttresses the Spinozist conclusion that the mind's primary focus is the body: "The mind exists for the body, is engaged in telling the story of the body's multifarious events, and uses that story to optimize the life of the organism" (Eakin, ¶ 25).

Conscious Awareness Associated with Accessing a Computer

Dennet (2001) explored the notion of consciousness and the research into this subject by neuroscientists in the field who have sought to define conscious thought. Dennet depicts unconscious acts as being processed in parallel distributed networks from the bottom up. Conversely, conscious processing utilizes a top down approach via an administrative center of interconnected neurons where information is organized, memorized, scrutinized; and subsequently actions are planned and acted upon. Dennett does not envision one specific structure that spawns consciousness, but specialized systems that become affiliated with one another. There is no specific region of the brain responsible for conscious acts, but the whole brain is engaged when brain signals—both input and output—become linked to each other. It is intrinsically difficult for researchers to accurately define an abstract concept such as consciousness. Nonetheless, there are signals that are recognized by the brain as meaningful, and neurons differentiate these signals as preeminent over others; therefore, these inputs are expressed as conscious awareness, and do not simply fall into oblivion.

Ochsner and Lieberman (2001) studied contemporary developments in the field of social cognitive neuroscience to explain the underlying neurophysiological basis for memory, emotion, attention, and language. Imaging studies have examined the structures of the brain involved in affective processes in response to particular circumstances, and how these reactions may be encoded in structures such as the amygdala. Other affective responses such as the formation of attitudes incorporate components of the nervous system that are involved in how persons may perceive a situation as positive or negative. The capability to judge meaning in a social context is a cognitive trait that is essential for socially acceptable behavior. The capacity to interrelate with one's environment or others, and the attitudes that influence decision making can be impaired in certain circumstances (most notably in conditions such as autism). In general, social cognitive science is concerned with theories pertaining to the underlying neural manifestations regarding self-awareness.

Unconscious perception in humans is somewhat of an enigma. Paradoxically, it still requires conscious perception to a certain extent, although the inverse may be true. Researchers have had subjects perform tasks in which they were given a clue that was supposedly unconscious in order to enhance their performance. Conscious and unconscious processing are independent contributors to memory tasks such as word completion. Furthermore, unconscious perception and unconscious influences of memory both contribute separately. Actions are one mode by which the mind controls the body. Actions require considerable information processing, albeit often unconscious. Roughly half of the neurons in the brain are involved directly in the motor actions. Thinking about moving or activating a neuron that directly innervates a muscle cannot independently effect movements. Conscious intent preceding a movement in order to achieve a goal is a key element in producing movements. These actions must be generative, and are much more elaborate than a straightforward reflexive response to a stimulus in the environment. Movement is predominantly sequences of active neuronal networks acting in concert with one another. Our actions and interactions with objects are embodied in internal models. There are systems that provide information that compare the predicted sensory consequences of movement with the actual sensory consequences to optimize motor control (i.e., self awareness and action). Studies suggest that we are aware of movements at a particular stimulus threshold that demands conscious intent. For example, when a person is required to manually trace a line to an object with only the capacity to see the line indirectly (i.e., have the line projected on a screen), some researchers have surmised that if the line is altered more the 15 degrees from a straight line path without the person's knowledge, the accuracy of the tracing is diminished. The accuracy of the tracing will not improve unless there is a conscious effort to maintain exactitude when tracing the line. There are no stimuli at the subconscious level that enable a person to achieve an accurate tracing in this circumstance. It is believed that we establish our movement patterns using the left posterior inferior parietal lobe of the cerebral cortex (Debner & Jacoby, 1994; Haggard, 2001; Blakemore, 2003).

Postural Control to Allow Computer Access

The vestibular system incorporates balance and posture, and is elemental to motor control affording stability during movement. The head, limbs, and trunk work in a synchronous manner to generate movements, while maintaining control of the body over the center of mass. Postural stability requires control of the head and trunk in space, since the trunk contains the majority of the center of mass (COM) of the body, and provides a stable base for the head that contains both the visual and vestibular system. The visual, vestibular, and proprioceptive systems interact in complex ways to maintain postural stability through coordinating the activation of the muscles in synergistic patterns. The muscles are activated by any or all of theses systems through nervous system control. The trunk muscles are activated prior to movements (feedforward mechanism) of the extremities. There are consistent preparatory movement patterns of the trunk with movements at the shoulder to give the extremity a stable base on which to move (e.g., trunk extension with shoulder flexion). The trunk stiffens up in the opposite direction of the extremity movement to counteract the movement to maintain equilibrium and control of the center of mass so a person does not move excessively or lose his/her balance. The fact that this occurs before the movement, and is consistent with the force of the limb movement to maintain stability, reveals a link between the arm and trunk muscles. A number of factors have been implicated in the maintenance of equilibrium when lifting, or during other interactions with the surroundings, that challenge vertical posture. Catching and releasing loads also demands muscle activation in the trunk and extremities. Everyday activities require movements in all directions (anterior, posterior, lateral, and rotational). The system that enables us to maintain vertical posture is versatile, and there are a multitude of options available for activating the musculature incorporating a surplus of muscles to obtain this objective. The CNS stabilizes the body and the muscles increase their stiffness in order to maintain stability. The CNS adapts muscle tone due to changes in the environment, and this adaptation is pre-established and not reactive to an unstable environment (Auruin, Tetsuo, & Latash, 2001; Buchanan & Horak, 1999; Burdet , Osu , Franklin, Milner,& Kawato ,2001; Hodges, Cresswell, & Thorstensson, 1999).

Neurological Conditions Observed in Persons Requiring Assistive Technology Interventions for Computer Access

The categorization of persons into those who are severe or profoundly disabled is somewhat arbitrary due to the variability between individuals who have multiple impairments. Frequently, this population has both mental and physical impairments. The term *severe disabilities* has been defined as: "… one whose ability to provide for his or her own basic life sustaining and safety needs is so limited, relative to the proficiency expected on the basis of chronological age, that it could pose a threat to his or her survival" (Severe Disabilities, 1990, ¶ 5).

Brain Injury

Disorders caused by severe brain injury can stem from a multiplicity of conditions that affect the CNS. Pathologies (i.e., various brain malformations) may arise before birth (prenatally). Disorders can also affect the brain at birth (perinatally) such as cerebral palsy (more fully explained in the following section). Cerebral palsy is a term that describes a wide range of problems that are thought to be a consequence of anoxia during the birth process. When a deficit in brain function is not present prenatally or perinatally, it is termed an acquired brain injury. Probably the most common acquired brain injury is traumatic brain injury (TBI). The most common etiologies of TBI are motor vehicle accidents, falls, or other accidents that harm the cortical structures of the central nervous system. Injuries can be penetrating with direct trauma to the tissues (bullet wound), or non-penetrating such as striking the head causing shearing, tearing, or ruptured nerve tissue or blood vessels with severed nerve pathways. The result is swelling in the brain or ischemia (decreased blood flow). TBI is more likely to result in diffuse axonal injury

(DAI) in children due to weak musculature of the neck and a higher head to body ratio; and also because of a lack of myelinization of the nerves. Acceleration/deceleration injuries in adults are usually more localized. TBI can be divided into primary or secondary injuries that can be focal or diffuse. Primary damage occurs concurrently with the actual accident. The primary injury is the trauma at the time of the accident (focal or diffuse) from tearing, swelling, or contusions. Secondary injuries pertain to metabolic changes or swelling not directly caused by the injury. Secondary effects are a result of the primary lesions, and can be influenced by medical interventions (Beers & Berkow, 1999; Fredericks & Saladin, 1996; Greenwald, Burnett & Miller, 2003; Rosenthal et al., 1999). Two basic causes of non-penetrating TBI are contact and acceleration-deceleration, with movement of the brain inside the skull that results in shear, tensile, or compressive strains causing bleeding. Damage will, in all likelihood, be more focal with contact injuries and diffuse (DAI) with acceleration deceleration injuries (Fredericks & Saladin, 1996; Rosenthal et al., 1999).

Cerebral Palsy

A specific etiology for cerebral palsy (CP) remains elusive. There is a broad range of motor deficits associated with the development of CP in early infancy that may or may not be directly related to CP, such as dystonia or hypotonia. CP has been described as a pediatric disorder that occurs prenatally or perinatally, damaging the central nervous system. This is not simply one discrete condition, but an umbrella term for a variety of unspecified deficits. Different forms of cerebral palsy have been described in the literature. The characteristics of movement patterns that are observed in early infancy are highly predictive for developing CP. Bracewell (2000) studied preterm (low gestational) children and the nature of their disabilities including cerebral palsy. He theorized that brain trauma originates in the antenatal, perinatal, and postnatal periods, although the incidence is not known for each of these periods. Diverse causes such as bleeding, ischemia, drugs or infections have all been implicated in cerebral palsy. The periventricular white matter is the brain structure most prone to injury. There is an urgent need for further study of the etiology of neurophysiological deficits in prenatal, perinatal and postnatal children (Bracewell, 2002; Stokes, 1998). Ådén et al. (2002) subjected mice (mature and immature) to ischemic hypoxia in an experiment to simulate the pathological process that leads to cerebral palsy. Imaging scans revealed lesions in a number of areas including the sensorimotor cortex, hippocampus, and striatum. Damage occurred earlier in immature mice and the long-term effects were more deleterious (e.g., impaired locomotor behavior), signifying that the immature brain is more susceptible to hypoxia with persistent long-term effects.

Cerebral palsy has been defined as "… neuromuscular deficit caused by a non-progressive defect or lesion in single or multiple locations in the immature brain resulting in impaired motor function and sensory integrity" (Bartlett & Palisano, 2000, p. 599). There is considerable variation in the type of impairments present and functional status of individuals who have cerebral palsy. Bartlett and Palisano have developed a model to distinguish primary deficits (present at the onset of the disease) and secondary deficits (a result over time from the primary impairment) in children with cerebral palsy. The researchers attempted to formulate constructs by which one can define the primary and secondary impairments, and derive a prognosis for function. This involved investigating the complex interaction of motor, sensory, emotional, and cognitive primary impairments, and their impact on secondary impairments and limitations of function. For example, spasticity (a primary impairment) causes contractures (a secondary impairment) and limits the range of motion of the ankles which in turn affects the ability to ambulate (limitation in function). Moreover, the significance of psychosocial as well physical elements should be emphasized when determining a causal relationship between the child's deficits and his/her functional capacity.

Other Conditions

There are also numerous disease processes that can induce brain injuries, most prominently infections, Parkinson's, cerebellar disorders, or strokes—among others. Strokes can happen at any age, and are predominantly a consequence of vascular insufficiency because of hypertension or atherosclerosis producing an embolus or thrombosis. Another manifestation of strokes may be hemorrhage with bleeding in the brain due to hypertension, arteriovenous malformation, or other causes. Encephalitis is an example of an infection that causes inflammation of the brain by a virus or other alien proteins with ensuing tissue necrosis (death) and demyelinization. Parkinson's occurs because of the paucity of the neurotransmitter dopamine in the basal ganglia inciting tremors, postural instability, rigidity of the muscles, and slowed movements. Parkinson's primarily affects central motor control and the ability to execute a voluntary movement engendering akinesia and bradykinesia. Rigidity affects the ability of muscles to lengthen due to the presence of a chronic shortening of the muscle tissues. The presence of tremors can also influence not only the ability to move, but fine motor activities (Beers & Berkow, 1999; Fredericks & Saladin, 1996). Some individuals, especially in the late stages of the disease, will develop cognitive problems that are associated with

Parkinson's.

Fredericks and Saladin (1996, p.486) define a stroke or CVA as "…the sudden and convulsive onset of a focal neurological deficit and refers to the syndrome that results from vascular disease of the brain." Ischemic events in the brain can be triggered by a thrombus or an embolus that clogs an artery decreasing blood flow to a focal area. Strokes can also be the result of a hemorrhage that compresses and damages tissue due to bleeding. There are various causative factors resulting in a stroke such as a cerebral infarct, hypertensive intracerebral hemorrhage, ruptured saccular (berry) aneurysm, ruptured arteriovenous malformation (AVM), arteritis, trauma, and other conditions. Strokes most often—but not always—occur in the geriatric population. Children and young adults can be stricken if they have a malformation of a vessel or abnormal heart function causing a clot (Palmer & Toms, 1992). Like any brain injury there can be multiple impairments after a stroke. However, focal damage is typically observed in a person with a stroke, rather than diffuse damage that occurs with TBI or congenital lesions. Hypotonia normally occurs immediately after a stroke and progresses to spasticity of the antigravity muscles. Weakness or the inability to generate force is present in the individual with a stroke due to central processing problems in the form of contralateral (opposite side of the body) hemiplegia or hemiparesis. Other problems have to do with the inability to perform fractionation of movements (moving a single joint without unnecessary movements in other joints) or associated movements (voluntary movement of one part of the body causing involuntary movement of another). There is also evidence of slowed reaction times, time to complete a movement, and time to stop a movement. Balance reactions are also found to be significantly impaired due to abnormal motor control on the paralyzed side. Not only movement related deficits, but a myriad of sensory, perceptual, memory, and cognitive deficits are found in individuals who have suffered a stroke. There are also a considerable number of individuals who have suffered a cerebrovascular accident that have speech and language problems. The presence of these specific impairments corresponds to the area of the brain that has been affected, but there may be substantial variability between individuals who have suffered an insult to the same region of the brain.

Cerebellar disorders can cause challenges when trying to coordinate movements, and stem from a variety of causes from congenital aberrations due to genetic and teratogenic factors, from metabolic abnormalities, or from an infarction (stroke). Fredericks and Saladin (1996) describe cerebellar conditions that cause "clumsiness" of movement secondary to impaired regulation of force, range, direction, velocity, and rhythm during movements to sustain a synergistic pattern of motion. Trunkal ataxia is also a symptom of cerebellar disturbances. This is evidenced by an inability to hold the trunk stable in concert with limb ataxia causing decomposition or a deterioration in smooth movements and movement quality. The eye muscles and muscles of speech (bulblar muscles) may also be affected in this manner. Muscle tone may be decreased (hypotonia) which causes further problems with targeting movements (i.e., reaching for an object) or stability during movements.

Rosenthal et al. (1999) reported on the multitude of motor problems that are associated with diffuse brain injury. There are two basic categories of movement dysfunctions, restricted motion and excessive motion. The ability to function in an environment can be limited by both of these syndromes. Spasticity in the arm with contractures or heterotopic (abnormal) bone formation can restrict reach in activities of daily living such as dressing. Contractures of the legs can impair walking. On the other hand, too much movement such as someone with cerebellar dysfunction may cause difficulties such as past pointing (i.e., the individual cannot press a button or grab a glass because of the inability to target their reach). Another example would be unstable posture, where a person generates too much force for a refined movement to transpire, and is unable to perform even basic tasks such as eating.

Observed Impairments as a Consequence of Central Nervous System Disorders

Fredericks and Saladin (1996) refer to the manifestations of neurological disorders as signs and symptoms. Although theses terms are often used interchangeably, they are not synonymous. A sign indicates an "objective" finding by a healthcare professional during an evaluation. A symptom denotes the deficits in function that are caused by the pathology or injury that are "components" of the condition or disease. Neuroscientists are still mapping the functions of the brain and many tasks are distributed throughout the brain and not localized to one region. A single pathological process can produce multiple impairments, making it problematic when attempting to assign causality with absolute precision during assessments of individuals with numerous disabilities. The inherent complexity of determining impairments and disabilities due to brain injury necessitates an intimate knowledge of neuroanatomy. However, these deficits can be broken down into four major categories: (1) behavior, (2) cognition, (3) communication, and (4) sensory-motor (Palmer & Toms, 1992).

Children with TBI display numerous impairments such as impaired communication, decreased acquisition of new information, distorted spatial orientation, limited attention and concentration, heightened impulsivity, diminished anger management, and flawed social skills (Moss, n.d.). The embryological development of the brain is a very intricate and multifaceted process, predisposing the child to abnormalities. Most of the problems with the brain are caused by genetic and environmental factors that affect the morphogenesis (formation of the brain) or histogenesis (development of the nervous tissue in the brain). Defects can occur in the formation of the cranium causing the brain to protrude. There is also a problem with nervous tissue that does not develop termed microencephaly. Injuries from the brain can occur due to abnormal fetal development, difficulties during birth, strokes, neurodegenerative disorders, and trauma. There is substantial variability among persons with respect to the deficits incurred as a consequence of brain injury, especially in the severely disabled (Palmer and Toms 1992). These conditions can result in a broad range of impairments in both the physical and mental function of the child.

Differences exist between the left and right hemispheres of the cortex with regard to impairments that may occur with lesions. The left hemisphere is dominant in most persons, and concerns itself with more structured verbal-analytical duties such as speaking or reading. Damage to the left hemisphere causes impairments such as: aphasia (inability to understand or formulate words), agraphia (incapable of writing), or alexia (unable to understand written communication). The right hemisphere manages visuo-spatial and perceptual activities. Deficits that can arise from lesions to the right hemisphere consist of: apraxia (inability to sequence movements), agnosia (unable to recognize objects), and astereognosis (cannot determine what an object is by feel).

Motor, hearing, visual, and sensory processing impairments occur bilaterally, irrespective of which cortex –left or right—sustains damage. (Palmer & Toms, 1992).

Motor Impairments

The most conspicuous problem seen in a person with a brain disorder is weakness or paralysis of the muscles. Muscle weakness seen in brain injury is due to impaired central activation of the motor units of the muscle. In comparison, peripheral weakness is caused by problems with the nerves outside the CNS or conditions affecting the motor unit of the muscle itself. Abnormal muscle tone is another deficiency observed in brain-injured persons with both hypertonia (increased muscle tone) and hypotonia (decreased muscle tone). The inability to coordinate movements is yet another sign of CNS disorders. Impaired coordination causes abnormal activation patterns of the muscles and movements at the joints resulting from a failure of the muscles to work in concert with one another. Muscle testing reveals the extent of weakness that may affect a variety of muscle groups, and may be partial (paresis) or total (plegia). Table 2 demonstrates some of the characteristic patterns of paralysis in the muscles of individuals with brain injury.

A range of signs are indicative of motor disorders some of which are: atrophy (muscle wasting), hypertrophy (abnormal increase in muscle mass), hyperactivity (increased tone), contractures (permanent shortening of the muscle), rigidity, impaired coordination, involuntary movements, and muscle fatigue. Disorders of the brain that cause muscle weakness are manifold, some of which are stroke, Parkinson's, traumatic brain injury, and cerebral palsy.

Frequently, muscle weakness is not an isolated occurrence in severe brain injury,

Table 2: Patterns of Muscle Weakness

Type of Weakness	***Definition***	***Common Cause***
Hemiplegia (or paresis)	Paralysis (or weakness) of muscles of the arm, leg, and sometimes face on one side of the body	Internal capsule, cerebral hemisphere, spinal cord hemisection, rarely a high cervical spinal cord lesion
Monoplegia (or paresis)	Paralysis (or weakness) of all the muscles of one limb—arm or leg	Spinal cord lesion, lesion in a cerebral hemisphere, peripheral neuropathy
Paraplegia (or paresis)	Paralysis of muscles in both legs	Spinal cord lesion, peripheral neuropathy
Diplegia (or paresis)	Hemiplegia or paresis combined with Paralysis (or weakness) of one limb On the opposite side of the body	High cervical spinal cord lesion or multiple lesions
Tetraplegia (or paresis) Quadriplegia	Paralysis (or weakness) of all four extremities	Lesion in high cervical spinal cord, Brainstem, or cerebral hemispheres, acute polyneuropathy or radiculopathy, myopathy

From *Pathophysiology of the Motor Systems* (p. 260), by C. M. Frederick, and L.K. Saladin, 1996, Philadelphia, PA.: F.A. Davis Company.

but is accompanied by other problems when damage to the brain is pervasive. Neural networks that coordinate movements or provide sensory feedback to assist with movement can suffer damage that will compound existing weakness or result in the inability to move, although true weakness is not present. Weakness is defined as the inability to generate force, but movement deficits are not that straightforward. The inability to initiate or control movements because of abnormal signals from the brain to activate muscles, inhibit unwanted activity, sustain contractions, maintain proper tone, or interact with the sensory systems such as vision will result in poor motor control. For example, a person may want to reach for an object, but they cannot produce fluid movements to direct the motion accurately in order to grasp. In addition, the fine motor skills involved in grasping or manipulating the object may not exist since the proper muscles are not activated or inhibited. A person with cerebral palsy may not have the ability to sustain muscle contractions and hold the arm in order to manipulate an object with the hand if they have quadriplegia with severe athetoid movements. Palmer and Toms (1992) looked at motor learning and motor control after TBI revealing true weakness, but also a lack of coordination of movement patterns (abnormal synergies). Impaired tone and spastic muscles result in postural instability. Patients can have cerebellar signs that may be manifested as ataxia (impaired balance), dysmetria (inaccuracy in targeting movements), dysdiadochokinesia (impaired alternating movements), and tremors, engendering non-fluid and erratic movements (Fredericks & Saladin, 1996; Stokes, 1998). Cranial nerve injuries are also present in brain injuries affecting motor and sensory functions. Burnett, Watanabe, & Greenwald (2003) evaluated common symptoms from brain injury indicative of cranial nerve injury in persons with TBI. Although many cranial nerve injuries may resolve on their own, there are cranial nerves controlling vision, swallowing, facial movements, and sensation that may be permanently damaged.

Central nervous system disorders impede the control of movements that come from the motor centers in the cortex and spinal cord, while the peripheral motor effector (motor unit) connected to the muscle remains intact—distinguishing a central from a peripheral disorder. Increased tone is defined as resistance to passive stretch of the muscle and is dependent upon the inactive elastic properties of the muscle tissue in conjunction with the active contractile elements of the muscle. Exaggerated muscle tone has different pathophysiological underpinnings. Muscles may be hypertonic with increased tone due to spasticity. In spastic muscles the amount of increased tone depends on the velocity at which you move the joint. Muscle rigidity is not velocity dependent, and remains constant no matter how fast the joint is moved (Burnett et al., 2003; Fredericks & Saladin, 1996; Stokes, 1998). Another example of altered movement patterns is impaired fractionation of movements. Fractionation of movements is the ability to control unnecessary movements at other joints while moving a single joint, necessitating coordination of movements through proper activation and inhibition of specific muscles. In brain injury, dysynergies emerge which are anomalous patterns of muscle activation where one movement causes other unintended movements. Movement timing is another problem of muscle activation where the time to initiate, complete, and stop a movement may be increased. Fredericks and Saladin (1996) and Stokes (1998) report on involuntary movements (Table 3) such as tremors, choreas, athetosis, dsytonias, and hemiballismus; all of which arise when there is a lack of central control to "restrain or direct" movements, most notably in disorders of the basal ganglia. Myoclonus is a brief series of quick jerks of a limb or part of the body. Persons with disorders that affect the basal ganglia may experience choreaform movements, described as jerky movements that shift from one part of the body to another. Intense large amplitude movements that affect various areas of the body are termed ballismus. Dystonia (previously athetosis) is a disorder in which regions of the body are twisted or contorted into atypical postures due

Table 3: Involuntary Movements

Movement	**Description**	**Common Site of Pathology**
Simple, Purposeless Movements		
Athetosis	Writhing, twisting movements occurring without fixed postures; seen most often in limbs, trunk, head, face, or tongue	Basal Ganglia
Dsystonia	Powerful, sustained contractions of groups of muscles that cause twisting or writhing of a limb or of the whole body; fast or slow, often painful; may result in gross deformity	Basal Ganglia
Chorea	Sudden, brief, irregular movements most often seen in distal muscles; usually random in character; not repetitive or rhythmic	Basal Ganglia
Dyskinesia	Certain choreic movements occurring repetitively at the same site, especially lingual-facial-buccal movements	Medication side effects
Hemiballismus	Large amplitude flinging or flailing limb movements, on one side of the body; ballismus if bilateral	Basal Ganglia
Tremor	Rhythmic oscillating movements frequently seen in fingers or wrists; vary in form; occur at rest, while maintaining a posture of the hand or wrist, or during voluntary activity	Many; especially basal ganglia and cerebellum
Nystagmus	Recurring tendency of the eyes to slowly drift in one direction and then quickly to correct back again	Many; especially cerebellum and peripheral labyrinth
Opsoclonus	Brief chaotic movements of the eyes often seen in children	Brainstem, especially pons
Myoclonus	Repetitive, brief, shocklike contractions of a single muscle or group of muscles; may occur sporadically or regularly	Many; including cortex, brainstem, and spinal cord

Table 3: Continued

Movement	Description	Common Site of Pathology
Complex, Semipurposeful Movements		
Tics	Repetitive, stereotyped movements, commonly occurring in the face and proximal limbs; occasionally simple but usually complex Higher centers; basal ganglia; largely unknown	Higher centers; basal ganglia; largely unknown
Rhythmias	Repetitive compound movements; usually side-to-side and to-and-fro movements of trunk, head, or neck	Cerbral Cortex
Akathesia	Movements of restlessness such as crossing and uncrossing legs, pacing, squirming in chair	Medication side Effects
Hyperkinesia	Excessive motor activity; impulsive, impatient, and labile behavior, especially in children	Cerebral cortex

From *Pathophysiology of the Motor Systems* (p. 278), by C. M. Frederick, and L.K. Saladin, 1996, Philadelphia, PA.: F.A. Davis Company. Copyright 1996 by F.A. Davis Company. Reprinted with permission.

to sustained contractions of certain muscles. This is often seen with cerebral damage perinatally. Associated reactions can take place when there is intentional movement of a part of the body, resulting in movement of another body part that cannot be repressed. Ataxia is the inability to regulate movements in a precise manner in terms of force, range, direction, velocity and rhythm, in order to move in a normal synergistic pattern. Ataxia may stem from faulty integration and processing of motor commands or sensory input, in which sensory pathways are giving erroneous messages to motor centers causing an incorrect motor response. Other coordination problems may include some of the following disorders. Dysmetria refers to a miscalculation of distance taking place during activities such as reaching. Dysynergia is difficulty with the timing or sequencing of movements. Dysdiadochokinesia denotes movement difficulties with respect to rhythm. Apraxia is a motor planning deficit in which a person is unable to sequence movements or recognize how to perform a task. Impairments that affect movement initiation and speed are termed hypokinesias and may include akinesia (very little movement generation) and bradykinesia (slowed movements). Balance is another motor deficit in which the musculature cannot aid in stability and equilibrium reactions in an individual due to faulty sensorimotor input and integration. Impaired balance is often combined with other factors such as weakness and contractures. Someone with a stroke may not be able to move because he/she has impaired equilibrium or cannot control the trunk or arms in space often overshooting or undershooting targets when attempting to direct movements (Fredericks & Saladin, 1996; Stokes, 1998; Viallett, Vuillon-Cacciuttolo, Legallet, Bonnefoi-Kyriacou, & Trouche, 1994).

Diffuse axonal injury (DAI) in TBI in which the axons of the white matter are essentially torn by shearing during an impact causing head rotation can result in significant impairments. The axons have a diminished capacity to withstand trauma, and these microtears are not apparent when utilizing current scanning technology. Injuries cause swelling and permanent damage to the axon, frequently occuring in midline structures such as the brainstem and corpus collosum. This often accompanies focal damage from a direct blow causing a laceration, contusion, ischemic infarction, or hemorrhage, and is virtually always present in severe TBI. Diffuse brain injury is generally referred to as a coup/contre-coup injury, where the brain hits the bony prominences of the skull, especially the orbital frontal and temporal tips, causing an embolism, hemorrhage, metabolic imbalance, hydrocephalus, or intercranial hypertension—among other problems (Rao & Lyketsos, 2000; Fredericks & Saladin, 1996).

Diffuse brain injury can cause a legion of deficits in comparison to focal brain damage. Deficits include significant hypertonus (increased muscle tone) or rigidity in the extremities, back, and neck. The most debilitating consequence of increased tone is contractures of the joints. Weakness can be manifested as hemiparesis (weakness on one side of the body) or quadriparesis (weakness on both sides of the body). The muscles innervated by the cranial nerves may also be affected causing weakness of the pharynx, larynx, and the tongue, inducing dysphagia or dysarthria—the inability to swallow or speak respectively. Muscles are more prone to fatigue and to aberrant patterns of movement with atypical activation and timing of movements. Apraxia, which is a disorder of motor planning and sequencing of movements and ataxia which causes disordered movement trajectories are also impairments caused by diffuse brain injury (Fredericks & Saladin, 1996).

Viallet et al. (1994) observed voluntary motor initiation and reaction time in persons with lesions to the supplementary motor area (SMA) of the cortex. The SMA is integral to programming of movements, whereas the primary motor cortex is mainly used to generate a movement. There appears to be a correlation between medial SMA damage and slowed reaction time in voluntary movements. The SMA represents higher movement centers that program movements in the extremities, and also implement stabilizing actions in the trunk. Someone with a brain injury may not be able to sequence their movements if they have damage to the left hemisphere in the frontal regions. Although they can move their arm and perform automatic movements when asked by someone else, they may be incapable of executing a particular movement in a certain context.

Other impairments that are present in persons with brain injury are affected by or contribute to impaired motor function. Balance both static (maintaining a position) and dynamic (stability during movements) deteriorate secondary to many underlying motor deficits such as weakness, sensory deprivations, vestibular deficits, and visual loss. Decreased consciousness and alertness are also indicative of brain lesions in which a person does not respond and is unable to concentrate to perform a task. Deficits in attention, memory, and executive function cause further difficulties with motor abilities. (Fredericks & Saladin, 1996; Smith, Maeney, & Sboll, 2003).

Sensory Impairments

Extremely debilitating sensory and perceptual problems are also observed in persons with brain injuries. Diminished sensation to pain, touch, temperature, and proprioception may appear in all regions of the body, occurring separately or together. One example of a sensory disability is an individual that has problems with visual tracking who may not attend to stimuli, causing problems with coordinated motor functions such as walking or reaching. Another scenario is a person that lacks sensory input from one side of the body (hemineglect) and may act as if that side of the body did not exist. Fredericks and Saladin (1996) comment on how central nervous system lesions affecting sensation beget diffuse sensory deficits in contrast to peripheral lesions that often have only a local effect. Lesions in regions such as the parietal cortex may potentially impact sensation on one side of the body for pain, temperature, touch, proprioception, and kinesthetic sense.

A combination of motor and sensory problems can restrict the function of individuals decreasing their independence with activities of daily living. Sensory problems emanate from the failure to convey and encode sensory input. A few examples are diplopia (double vision), decreased arousal (impaired reticular activating system), and the inability to filter sensory input causing problems attending to and reacting normally to sensory input. Motor problems are worsened by impaired sensation, body image, and position sense. Moss (n.d.) documents the need for a comprehensive ophthalmologic exam for persons with a brain injury. Abnormal function of the eye muscles (strabismus) with double vision or an inability to focus is a common problem. Visual processing deficits cause the person to have difficulty with spatial orientation (e.g., the person flexes their head or holds it to the side in an abnormal posture while sitting up because they perceive this as normal vertical orientation). There should be an evaluation of vision and how this relates to kinesthetic, proprioceptive, and vestibular functioning. Visual disturbances are known to be very prevalent in persons with brain injury, and are often overlooked as a source of impaired functioning.

Perceptual Impairments

Laurent-Vannier (2003) studied unilateral spatial neglect in young children. This condition has been well-documented in adults, but is not as evident in children. Damage to the parietal or possibly the superior temporal regions may be the cause of hemineglect. The authors document case studies in which children ignore stimuli in the opposite (contralateral) spatial region when this disorder becomes apparent. Visuospatial orientation to external objects can be impaired with lesions to the posterior parietal lobe (PPL). Vertical orientation of the trunk and head has been tested between normal control subjects and those with posterior parietal lesions of the left or right hemisphere. PPL lesions on both sides affect vertical orientation of the body in space, but have little effect on horizontal orientation (Darling, 2002; Postma, Sterken, de Vries, & de Hann, 2000). Spatial orientation is critical for balance and movement. Reports on brain injury and perceptual deficits with regard to spatial localization reveal that multiple brain locations are involved, and deficits may differ according to the context in which the patient is asked to function. Postma et al. investigated persons with unilateral posterior brain damage and their performance on perceptual and visuomotor localization tasks. Both left and right hemispheric damaged patients performed worse on the perceptual localization tasks. Visuomotor tasks were not as impaired, but subjects showed aberrant movement with damage to the visual fields (left and right hemispheres). Problems with reaching were noted when the right hemisphere was involved. There are qualitative differences between the left and the right hemisphere. The dominant hemisphere for spatial perception is thought to be the right hemisphere, but this may depend on the situation. Moss (n.d.) delineates the characteristics of post trauma vision syndrome (PTVS) including those listed in Figure 6.

Neuropsychological Impairments

Mood, behavior, and cognitive disorders comprise the main neuropsychological deficits following brain injury. A wide range of conditions have been diagnosed following TBI. There are numerous cognitive disorders such as decreased arousal,

- **Difficulty with binocular vision function**
- **Difficulties with accommodation**
- **Low blink rate**
- **Inability to perceive spatial relationships between and among objects**
- **Difficulty fixating on an object and pursuing the object visually when it moves**
- **Abnormal posture**
- **Double vision**
- **Clumsiness**
- **Objects appear to move when they are not moving**
- **Poor concentration and attention**
- **Poor visual memory**
- **Inability to perceive the entire picture or to integrate its parts**
- **Inability to read despite the ability to write**
- **Failure to attend to objects presented in a particular place**
- **Inability to recognize objects with their vision alone**
- **Inability to distinguish colors**
- **Inability to visually guide their arms, legs, hands, and feet**
- **Visual field loss**

Figure 6: Post Trauma Vision Syndrome

attention, concentration, memory, language, and executive function. Disturbances in awareness, memory, and affect are the most conspicuous impairments, with memory deficits being the most prevalent. Loss of memory may occur for both verbal and nonverbal skills (Rao & Lyketsos, 2000; Borgaro & Prigatano, 2002). Disturbances of executive function include a compromised ability to effectively plan, organize, or shift attention along with poor judgment and impulsiveness. Anxiety, depression, irritability, apathy, and fatigue are mood disorders common in TBI. Uncontrollable behavior, emotional lability (instability), disordered thought processes, disinhibition, agitation, and akathesia are classified under behavioral syndromes. Additionally, sleep-wake cycles may be interrupted. All of these maladies are generally not seen in isolation, but more often than not, occur concurrently (Burnett et al., 2003; Rao & Lyketsos, 2000).

Hellawell, Taylor, and Pentland (1999) looked at moderate to severe brain-injured individuals at 6, 12, and 24 months post injury to determine the neuropsychological ramifications associated with the degree of severity of the brain injury. The relationship between impairment and disability in brain injured persons is ambiguous, confounding attempts to determine cause and effect. In global measures of disability for brain injury there are many factors that contribute to the severity of an injury, and it is not always possible to predict functional outcomes. Hellawell, Taylor, and Pentland conducted a study demonstrating a correlation between poorer outcomes and the seriousness of the injury, revealing uncertainties regarding any direct cause and effect relationship. This may simply be a reflection of the person's overall function, rather than a true measure of his/her ability.

Attention and Awareness Impairments

Attention deficits are commonly observed in brain-injured individuals. Attention is a somewhat enigmatic term; however, persons with brain injury may be distractible. This may be evidenced by the inability to concentrate, attend to multiple tasks, or filter out extraneous stimuli. There are different components of attention that require children and adults to be cognizant of two competing stimuli simultaneously, perform feature extraction, identify sensory input, react selectively to stimuli, and adjust motor responses. Studies outline various facets of attention such as the startle response, orienting response, selective attention, vigilance, and divided attention. Studies have uncovered deficits in brain-injured persons on visual and auditory tests of attention (Fenwick & Anderson, 1999; O'Donnell, 2002; Rosenthal et al., 1999). In order to discriminate between the profusion of sensory stimuli converging on the cortex at any given time, a compendium of cognitive and other neural functions constitute what is exhibited as attention. Particular subtypes of attention may be considered to be passive (startle and orienting response), and can be instigated without conscious effort. Brain injuries may also cause poor orientation, hyposensitivity or hypersensitivity to stimuli. Other problems with attention may be the inability to "filter" out information (selective attention) due to poor processing by the individual (frontal or posterior parietal injuries). Vigilance (sustained attention) is greatly affected by brain lesions to regions such as the brainstem, midbrain, frontal lobe, and parietal lobe. Divided attention needed to perform multiple tasks is another area that can be affected (O'Donnell, 2002).

Stierwalt and Murray (2002) report that damage to the frontopolar, orbitofrontal, anteriotemporal, and lateral temporal areas of the cortex affect attentiveness, and that these areas may be the primary areas in the cortex implicated in attention tasks. Attention deficits can cause problems in other areas such as memory (encoding and storing), problem solving, and understanding or expressing language. Castiello and Paine (2002) studied covert attention in perinatal injury of the parietal cortex. Castiello and Paine defined their condition of observation as "orienting in the absence of explicit eye or body movements." Castiello and Paine specifically looked at motor attention and visual attention which is a precursor for preparation for hand movements. An individual missing the left hemisphere was studied in relation to a control subject, and given a "valid" or "invalid" cue to prepare for a certain movement. The individual with the brain injury was found to have a significantly greater latency with regard to reaction time when verbally cued to make the wrong movement (invalid cue). This action requires conscious monitoring and self-correction, showing a deficit in the ability to shift covert attention with a brain injury. Castiello and Paine hypothesized that this may be a function of the left parietal cortex, while oculomotor function may be present in the right parietal cortex.

Fenwick and Anderson (1999) give further scrutiny to attention deficits in children with damage to the cortex. Fenwick and Anderson postulated that children with developing brains would show “global” changes, whereas adults would display “focal” deficits in attention. Fenwick and Anderson discovered focal deficits in children, yet there was a qualitative difference in contrast to adult patterns of dysfunction. However, since attention is not fully developed in children, the findings may not be comparable with those in adults. Daffner et al. (2000) looked at attention problems in persons with frontal lobe damage. They evaluated attention using three different modes for projecting images: repetitive images, a target object, and a novel stimulus. Subjects pushed a button and held it while looking at these objects. They were instructed to look at an object in a sequence, and the researchers measured how long the subject fixated on an object in a sequence of three image presentations. It was determined that the brain injured (frontal damaged) subjects paid less attention to novel stimuli.

Behavioral Impairments

Another manifestation of brain injury that is frequently encountered is emotional lability (unstable behavior). Behavioral or emotional problems are often linked to damage to the prefrontal areas of the cortex. These regions shape emotional perception and are connected to the limbic system which is associated with feelings, affect, and state of mind. Behavioral changes have been noted in brain injury (particularly after TBI) including an impaired awareness of disability (agnosognosia-lack of insight or denial). Other problems may include episodes of uncontrollability, disinhibition, or the inability to manage mood state. These persons may be apathetic, fatigue easily or have a decreased level of arousal. (Palmer & Toms, 1992; Rosenthal et al.,1999). Social skills or interaction may also be an area in which problems are noted. Distinctions can be made between hemispheres with regard to the types of behavioral problems that are observed. A left hemispheric lesion causes despondency, depression, and agitation. In contrast, right hemispheric lesions result in apathy, passivity, and comparative serenity. (Palmer & Toms, 1992).

Cognitive Impairments

Rosenthal et al. (1999) delineate cognitive deficits in brain injured individuals for areas related to language production, intellect, memory and learning, attention, and executive function. Deficiencies in language and communication can materialize in conditions such as dysphagia that affect language production for conversation and naming. Impediments to intellectual functioning can be present depending on the severity of the injury. Memory deficits also impair learning influencing registration, storage, and retrieval of information. Diminished executive function is thought to be related to frontal lobe damage thwarting the control of a wide spectrum of cognitive functions. Fredericks and Saladin (1999) suggest that not only cortical damage, but sub-cortical damage in conditions such as Parkinson’s disease, can cause emotional and cognitive difficulties. Cerebellar disorders have also been recognized as precipitating cognitive deficits in areas such as verbal and nonverbal intelligence, memory, and other higher order processing functions. Metacognitive skills are one aspect of executive function of the brain located in the prefrontal region. Theorists have differing viewpoints concerning metacognition, which in essence means conscious awareness of one's cognitive abilities. A different use of the term metacognition is the product of an information processing approach to theoretical models of cognition which assumes a system whose activities and resources are monitored by a “central executive” (Haten, 2000). Children gain the ability to predict and monitor their thought processes as they mature. Many of the most disabling effects of brain injury coincide with the functions found in the prefrontal area. Subjects have shown maladaptive behavior associated with emotions, social conduct, and decision making. Many standard neuropsychological tests are not valid assessments of cognitive impairments found in persons with cortical damage. (Anderson, 2000; Haten, 2000).

Christ, White, Brunstrom, and Abrams (2003, ¶1) defined executive ability as “…a broad term used to describe an assemblage of higher order cognitive abilities such as strategy use, cognitive flexibility, and inhibitory control.” The prefrontal cortex is the center that controls executive function, with white matter connections in other regions of the brain. The prefrontal cortex is also thought to develop later than any other part of the brain. In contrast, Elliot (2003) describes executive function as an ill-defined term for abstract thinking associated with the frontal cortex. However, executive functions may be more widely distributed in the cortex than just in the frontal cortex, extending into the striate region of the sub-cortex on neuroimaging studies (distributed processing). Elliot illustrates executive functioning as co-coordination of varied subtasks to realize a distinct objective. Brain injured persons may not have problems with one particular task, but commonly display impediments when endeavoring to coordinate multiple tasks. Children with bilateral spastic cerebral palsy (CP) with damage to the white matter tracts linking various regions of the brain lacked the ability to repress their initial reactions in a study in which children were called on to change an initial premeditated response in order to react appropriately. The outcome demonstrates problems with inhibitory control, and slowed processing in CP children. The timing of an injury (i.e., the age that it occurs) may also be a factor in the onset or severity of cognitive impairments (Christ et al., 2003).

Adults with TBI have shown a diminished capacity to “know” even in the absence of memory deficits. This phenomenon has been less well documented in children. Haten (2000) studied a cohort of children to determine ease of learning (EOL) to predict how well an individual might learn a subject; and judgment of learning (JOL), denoting when an individual is cognizant of how well they are learning something. The data revealed that frontal damage is associated with decreased metacognition in TBI, even without memory impairment. Furthermore, the problem may be made worse in the presence of diminished memory abilities when the child tries to pick and initiate “strategies” for learning and reflecting on learning. Traditionally, the consensus has been that early brain damage improves due to plasticity of the immature brain, but different brain areas and cognitive domains may show different levels of repair with time. Young children with damage to the memory and speech areas of the brain may not manifest any problems or only subtle problems later on compared to their adult counterparts. Early damage to simpler language, motor, or sensory areas may improve significantly in children; however, contemporary research reveals that more complex cognitive functions may not recover because they may be structured relatively early during brain development. Furthermore, higher order thinking may necessitate environmental stimuli early on in order to properly develop. Certain functions, especially verbal, are compensated for in children to a certain extent. Even if the child approximately 4-5 years old has a hemisphere removed, since the brain is not fully developed, any impairments are independent of the hemisphere that is removed, unlike in adults. Early damage in the prefrontal area may impede the acquisition of crucial elements that provide the keystone for later development. It is also plausible that lesions in many different areas may coalesce during development to cause even greater disabilities later on (Anderson, 2000; Vargha-Khadem, 2001).

Clinical assessment of frontal lobe lesions is especially challenging due to the myriad of functions present in this region. Appellations that have been attributed to this area are the executive region, supervisory system, and the control area in addition to others that are fairly nonspecific. Anatomically, the frontal lobes are divided into areas of more explicit functions, with identifiable nerve pathways that connect to the subcortical regions, all of which are subsumed under the frontal cortex. Many functions of the frontal lobe also occur in other areas of the brain and are not isolated in the frontal cortex. There are several theories regarding what constitutes the functions of the frontal lobes, with elements such as attention, language, and memory implicated in the research literature. This engenders a need to explain what aspect of attention, language, memory or executive tasks are engaged in the frontal lobes. This exemplifies the problematic nature of defining or operationalizing executive dysfunction when lesions of the cortex are present. The non-cognitive functions of the frontal lobes have been delineated as social and behavioral functions, personality traits, affective-responsiveness, self awareness, and consciousness. Frontal lobe pathology has implications for everyday problem solving activities. The frontal lobes deal with abstract thought processes, and provide the means by which an individual can evaluate different forms of input to the brain. A battery of neuropsycological tests of executive thought—abstract reasoning, memory, shifting responses, and tests related to everyday functioning—reveal that persons with frontal lesions (especially left frontal lobe lesions) are poorer in problem-solving ability, such as impaired judgment and choice of action, impaired interpersonal skills, decreased practicality, and decreased self-awareness of impaired decisions, with or without the presence of limited memory or language comprehension (perceptual abilities). Individuals with frontal lobe damage also lack insight into how past experiences can affect present situations, and the consequences of these actions (Alexander & Stuss, 2000; Channon & Crawford, 1998).

Memory Impairments

Memory deficits are common in brain injury. Memory can be divided into implicit (procedural) and explicit (declarative). Procedural memory is the capacity to remember how to do something; declarative memory is remembering what you have done in the past. Impaired explicit memory is most commonly observed in persons who have sustained a TBI, and is thought to be the result of damage to the hippocampus and medial temporal lobes, although other regions have been implicated (Maguire, Vargha-Khadem, & Miskin, 2001; Ward, Shum, Wallace, & Boon, 2002). Stated in another context, but with the same basic connotation, memory has been assessed in persons with brain injuries and immediate recall was not affected, but delayed recall (defined as greater than 10 minutes) was altered. Cueing may assist in recall, although there continues to be a disparity in the performance of brain-injured patients compared to normal controls. Most research has been performed using adult subjects. Yet, a study of children with TBI found considerable inaccuracies in explicit memory compared to implicit (recall vs. recognition) with damage to the frontal lobes, hippocampi, and medial temporal regions (Larsson & Ronnberg, 1987; Ward et al., 2002). Maguire et al. (2001) examined a patient with hippocampal damage in relation to non-injured individuals on memory tasks. Damage to the hippocampus is thought to impair explicit memory (past autobiographical memory) and semantic events, although little correlation between laboratory tests and real-life memories has been found. Testing using scanning techniques such as Functional Magnetic Resonance Imaging (fMRI) during memory tasks may be more accurate at providing clues to the types of memory associated with different parts of the brain. In their study Maguire et al. evaluated a young male with a hippocampal lesion with impaired episodic memory in comparison to normal individuals on memory tasks for retrieval of real-world memories using fMRI. Results showed that several areas were activated in all of the subjects, but additional areas were operational in the brain injured subject. The subject with the lesion activated numerous regions that the controls did not utilize, incorporating homologous regions in the right hemisphere, and in the prefrontal cortex bilaterally to retrieve a memory. The brain-injured subject also exhibited distinctive activation patterns and intercommunication between different brain regions. He showed more normal activation when he knew about the presented event, but if he was not aware beforehand, the activation pattern changed. This brings to light a remember/know distinction based on neurological function. However, the brain-injured subject still required activation of additional pathways compared to controls even if he was cognitive of the event precipitating the memory.

Assessment for Assistive Technology Devices for Computer Access

In the Miami Dade County Public Schools Office of Exceptional Student Education and Student Career Services—Assistive Technology Assessment Procedures (n.d.), a policy has been promulgated stating that AT is not for instructing a student in a specific subject, but to remediate or accommodate physical and learning problems using hardware or software. This distinguishes AT from instructional technology software. Instructional technology is utilized to assist a student in need of remediation to improve learning in a particular subject(s) such as math or reading. This is the mode in which the consideration of AT should espoused according to this strategy. One must consider AT in light of the person's disability as it affects the ability to learn, not their performance or aptitude in various subjects. Consideration of assistive technology services entails an evaluation or assessment process delineated in the following IDEA regulatory statute:

> **§ 300.6 Assistive technology service**
>
> As used in this part, *Assistive technology service* means any service that directly assists a child with a disability in the selection, acquisition, or use of an assistive technology device (Council for Exceptional Children, n.d.; Minkel, 2002).
>
> The term includes:
>
> (a) The evaluation of the needs of a child with a disability, including a functional evaluation of the child in the child's customary environment;
>
> (b) Purchasing, leasing, or otherwise providing for the acquisition of assistive technology devices by children with disabilities;
>
> (c) Selecting, designing, fitting, customizing, adapting, applying, maintaining, repairing, or replacing assistive technology devices;
>
> (d) Coordinating and using other therapies, interventions, or services with

> assistive technology devices, such as those associated with existing education and rehabilitation plans and programs;
>
> (e) Training or technical assistance for a child with a disability or, if appropriate, that child's family; and
>
> (f) Training or technical assistance for professionals (including individuals providing education or rehabilitation services), employers, or other individuals who provide services to, employ, or are otherwise substantially involved in the major life functions of that child.
>
> (Council for Exceptional Children, n.d.)

In the assessment phase for assistive technology there must be a trans-disciplinary assemblage of competent team members. The assessment should contain an appraisal of the disabling condition in regards to functional activities that the student must carry out, and the goals of the student and significant others.

In "Quality Indicators for Assistive Technology in School Systems" Zabala (2000) reported on a dearth of standards in addition to insufficient knowledge and training regarding the provision of AT services. These impediments to the provision of effective AT services have prompted the formation of the Quality Indicators for Assistive Technology (QIAT) Consortium. There are numerous barriers to the dispensation of effective AT services such as ambiguous goals, the lack of a team approach, the inability to understand the complexities of AT provision, and preconceived notions by the staff that impede the use of AT. The raison d'être for the QIAT indicators is an attempt to enhance the assessment and provision of AT for persons with disabilities, taking into consideration the student, family, and school personnel. The QIAT has a website and its members meet regularly to formulate and revise the list of indicators. These include indicators for assessment detailed in the following:

l. Assistive technology assessment procedures are clearly defined and consistently used.

Intent: Throughout the educational agency, personnel are well informed and trained in assessment procedures and how to initiate them. There is consistency throughout the agency in the conducting of assistive technology assessments.

2. Assistive technology assessments are conducted by a multidisciplinary team that actively involves the student and family or caregivers.

Intent: The multidisciplinary team conducting an assistive technology assessment is comprised of people who collectively have knowledge about the abilities and needs of the student, the demands of the customary environments, the educational objectives, and assistive technology. Various team members bring different information and strengths to the assessment process.

3. Assistive technology assessments are conducted in the student's customary environments.

Intent: The assessment process takes place in customary environments (e.g., classroom, lunchroom, home, playground, etc.) taking into consideration the varied characteristics and demands in these environments. In each environment district personnel, the student and family, or caregivers are involved in gathering specific data and relevant information.

4. Assistive technology assessments, including needed trials, are completed within reasonable time lines.

Intent: Assessments are initiated in a timely manner and completed within a time frame that is reasonable as determined by the IEP team. The time frame complies with applicable state and agency requirements.

5. Recommendations from assistive technology assessments are based on data about the student, environments, and tasks.

Intent: The assessment includes information about the student's needs and abilities, demands of the environments, and educational tasks and objectives. It may include trial use of the technology in the environments in which it will be used.

6. The assessment provides the IEP team with documented recommendations about assistive technology devices and services.

Intent: The recommendations from the assessment are clear and concise so that the IEP team can use them in decision making and program development.

7. Assistive technology needs are reassessed by request or as needed based on changes in the student, environments, and/or tasks.

Intent: An assistive technology assessment is available any time it is needed due to changes or when it is requested by the parent or other members of the IEP team.

Frequent problems that are observed during the assessment process are:

Common Errors:

1. Procedures for conducting AT assessment are not defined, or are not customized to meet the student's needs.

2. A team approach to assessment is not utilized.

3. Individuals participating in an assessment do not have the skills necessary to conduct the assessment, and do not seek additional help.

4. Team members do not have adequate time to conduct assessment processes, including necessary trials with AT.

5. Communication between team members is not clear.

6. The student is not involved in the assessment process.

7. When the assessment is conducted by any team other than the student's IEP team, the needs of the student or expectations for the assessment are not communicated.

Assessment Procedure

The importance of AT in schools for persons with disabilities cannot be overemphasized. Yet, figures from 8%-80% have been quoted for abandonment depending on the time period and type of technology. This is often due to a lack of inclusion of the individual or his/her family in the decision making process for an AT device. This permits the family to become “passive recipients” of AT, and dependent upon professionals who do not possess any ownership of the technology. AT should be better integrated into the daily needs of the individual through the advocacy of others such as the family, and all persons involved with the child should have a stake in whether or not AT interventions are a success. When families are consulted and intimately involved in all decision making and goals, the technology is more apt to be utilized in the person’s environment.

A medical model for AT assessment is child-centered, where the professional chooses what device will help the child, excluding the child and family from the decision making process. A family-centered model stresses the family as directing the course of the assessment. An educational model focuses on the child and success is measured by educational goals. The family contributes to the assessment, and they are trained to use the technology in the child's natural environment. If there is no collaboration by the team the technology is doomed to failure (Judge, 2002; Minkel, 2002; Parette, 1995; Sparks, 2000; Trefler, 1992). Many professionals see a child for an assessment in isolation using "traditional assessments" that evaluate tasks that are not generalizable to real-world settings to augment levels of functioning in the individual. It is crucial to involve the family in all steps of the assessment from the initial screening, through trial use, and follow-up (Judge, 2002). The decision on the device should be made by heeding mutually agreed-upon goals between the individual receiving the device, his or her significant others, and the assessment team (Minkel, 2002).

Parette (1995) specifically looked at approaches in early-intervention programs for AT, emphasizing the need to take into account the goals of the family in a naturalistic setting, and the need to utilize a team approach to evaluate physical, cognitive, and emotional development when constructing the Individualized Family Service Plan (IFSP). Family involvement suggests cultural issues that must be addressed along with family expectations to improve acceptance of the technology. There is a vast array of issues associated with the assessment of needs for assistive technology from a culturally sensitive, family-centered perspective. Parette outlines five domains that should be considered when prescribing an AT device including the: (1) child, (2) technology, (3) service system, (4) family, and (5) culture. *Child* factors refer to the needs of the child;

that is, his or her capabilities, interests, and the goals that are established for him/her. *Technology* factors include the new opportunities and added demands the technology will place on the child and his/her family. An analysis of *service systems* incorporates considerations such as limitations, demands, and resources available to the family from all possible sources. *Family* factors require an analysis of relevant background variables in the complete family system, including family needs, strengths, styles, resources, and preferences. *Culture* denotes customs, values, and beliefs that are unique to family members and children from a distinct cultural group. There are differing viewpoints on how to approach the family and involve them in AT assessments, taking into account ethnic and cultural differences, as well as other societal factors (e.g., resources and family dynamics).

In the article "What Makes a Good Evaluation/Assessment for Assistive Technology" by the Increasing Capabilities Network" (ICAN) of Arkansas Rehabilitative Services (n.d.), the individual and the family or caregivers are the principal element of the assessment team because of their exceptional acumen regarding what is needed for a successful outcome pertaining to AT. However, Minkel (2002) remarks that the prior experience of the individual or family with assistive technology devices and services will have some bearing on the extent to which there is active participation in the assessment process. The expertise of members of the assessment team such as physical and occupational therapists who evaluate motor skills, perceptual ability, mobility status, positioning, and other areas are likewise, extremely valuable to the process. In Minkel's view a strong team approach to assessment led by an AT specialist who sees the child after the rest of the assessment is completed in order to make the final decision on what device to procure is elemental to the success of any AT device. The team should be comprised of a teacher, occupational therapist, physical therapist, psychologist, and speech language pathologist. The most common disciplines to prescribe AT are physical therapists, occupational therapists, speech therapists and educators (ICAN, n.d.; Lahm & Sizemore, 2002). There is also a need for a partnership with audiologists, social workers, physicians, and other specialists as required.

The steps taken in order to gain access to an AT device include the referral, team meeting, evaluation, trial period and written report (ICAN, n.d.; Chadow, 2000). I will focus on the evaluation or assessment process. Generally, an AT assessment originates by having the team investigate the person in his/her environment, and procure background information such as the past medical or educational history. The AT team may start by examining the individual's postural alignment, sensation, muscle tone and strength, range of motion, and other physical characteristics. There may also be an evaluation of fine motor skills, vision, learning, language, memory, and cognition. The assessment must take into consideration the environment and tasks. After a trial period using the AT device, repeated assessment and reassessment must be done to insure the correct device is selected (ICAN, n.d.).

Lahm and Sizemore (2002) were concerned about the qualifications and methods used by persons employing AT assessments. They conducted a study probing whether persons involved in AT assessments used a functional, clinical, or another model for AT assessment, compiling data on attitudes, background, and training. The survey revealed that all of the persons interviewed used a functional approach to assessment with the exception of AT suppliers who used a clinical approach, yet had the least amount of expertise. Most professionals advocate a team approach in a natural setting based on the client's goals, but rarely adhere to this modus operandi.

Surveys allude to the hundreds of assistive technology assessment tools that are available, presenting a quandary regarding which forms or tools work the best. In the school environment, the teacher is the primary contributor to the assessment in conjunction with outside specialists such as a physical therapist, an occupational therapist, or a speech therapist. Heretofore, there has been no specific information regarding the roles of the various disciplines and their responsibilities in the AT assessment, and whether or not they use a clinical or a functional model. Lahm and Sizemore (2002) and Sparks (2000) portray the evolution of a team-centered approach to assessment, including the family, administered in an individual's customary environment. This replaces the traditional rehabilitation model that uses a clinical approach in an office setting with the professional furnishing an assessment of cognitive and motor abilities. There are various tools for assessment—checklists, ratings, narrative, observation—but the general categories that should comprise any assessment are observations of the student, environment, tasks, and tools (SETT) according to Sizemore and Sparks. It is not that one assessment instrument is necessarily better than another, but there are certain criteria that should be met in any assessment. The medical or academic history may be obtained. Specific areas can involve physical abilities including: hearing, vision, tactile sensations, coordination, mobility, and range of motion. Other measures that are integral to a complete assessment are cognitive/linguistic awareness for comprehension and expressive and receptive communication. Emotional responses are often overlooked, but are noteworthy for evaluating a person's reactions to stimuli, attentiveness, personal/

interpersonal relationships, and awareness of his/her environment. The supportiveness of other students, teachers, and family must be established in order to know what type of challenges will be encountered when determining the proper device. Environmental concerns are also critical, since this may impact how the child will utilize the technology. The assessment must address goals that are realistic and meaningful to the student, enabling him/her to function in a manner that is pertinent to his/her needs and allows a measure of autonomy. Using testing, interviews, and observation, data is collected to identify devices that may be effective, operable by the student and family, and compatible with the student's needs. The trial devices are evaluated by the team with various considerations taken into account during this process. Above all, the assessment needs to be honest, accurate, and meticulous. It is of no benefit to the student to disingenuously assign him/her abilities which they do not truly possess (Sparks, 2000; Technology Resources for Education, n.d.).

Chadow (2000) advocates a holistic approach to the assessment of individuals during the provision of AT services. When a child cannot accomplish a task there is usually more than one reason. Normally there is a conglomeration of impairments that cause functional deficits. For example, a child may not be tracking visually, yet this may not be exclusively a visual problem, but may also be a consequence of impaired motor abilities as a source of poor head control. A determination should be made as to whether the child has fine motor deficits and did not develop tracking ability, or in actuality does have a visual problem. This will have significant bearing on the course of action that should be taken to address this limitation. According to Chadow there are multiple steps to obtaining an AT device including: step 1- referral, Step 2- assessment of physical, cognitive and visual impairments (excluding the AT specialist), Step 3- team meeting, Step 4- AT specialist assessment, and Step 5- recommendations by the team.

The individual with a disability must be at the center of any assessment process, and the assessment must be undertaken in his/her own environment. There is a lack of comprehensive assessment programs in the field of AT for computer access. While these assessments may offer checklists, profiles, and forms; there are no guidelines for the assessment, and no direction to help with the discrete problems of the individual and his/her family. An individual must be motivated to use a device, or the intervention will not be successful. The device should correspond to the individual's psychomotor skills, and must serve a purpose in order to be acceptable to that individual in his/her unique social environment (Biegal, 2000; Hutinger, 1998). Further problems consist of a lack of a team assessment to allow collaboration between the professionals and the family or caregiver. Social, emotional, cognitive, communication, and physical components should all be taken into account when prescribing assistive technology.

Assessment Models

Ashton (2002) depicts the nature of the assessment format using the Area Cooperative Educational Services (ACES), a model that ensures assistive technology services focus the assessment process based on educational objectives. This includes a pre-referral and a referral phase. The referral phase uses an assessment form, the ACES Assistive Technology Services Referral Form, to evaluate the needs of the child to develop background information, and collect information in areas to determine the child's abilities, limitations, and other pertinent information such as available resources. This protocol allows an assessment of the individual in order to arrive at the best possible decision based on the educational needs outlined in the IEP (Appendix A).

The Technology Team Access Project (TTAP) developed an assessment process (Tech Access) that formalizes and structures the assessment, and is largely intended for use with young children (Huntinger, 1998). The TTAP focuses on young children with moderate to severe disabilities and was developed by the Center for Best Practices in Early Childhood Education at Western Illinois University. The purpose for the assessment was to enable appropriate use of AT for hardware and software needs, and also the proper positioning of the child to determine where modes of access should be placed in order to allow accessibility by the child. The assessment team is comprised of a core team (early childhood intervention expert, technology expert, psychologist, occupational and physical therapist, and communication specialist) and a child support team (family, child’s teacher or development specialist, school psychologist, and child’s physical, occupational or speech therapist). Positioning, activities of daily living, and communication abilities are evaluated by the physical and occupational therapists, whereas the speech therapist or the school psychologist may assess cognitive and emotional levels. The work of the team provides a comprehensive assessment of a variety of areas.

Bromley (2001) compares five assistive technology assessment models. The Matching Person and Technology (MPT) model spotlights the user and his/her needs and goals in addition to family, environmental, and economic factors. This model is amenable for use primarily in adults, and utilizes questionnaires. The evaluation culminates in a worksheet that is used to determine the correct device. The Lifespace Access Profile for Individuals with Severe or Multiple Disabilities is a client-centered team approach to AT assessment. This evaluation is comprised of five areas including: physical resources, cognitive resources, emotional resources, support resources, and environmental analysis. The physical assessment is comprised of areas such as general health, mobility, support, and body places for access. The cognitive resources section encompasses functions including the comprehension of cause and effect and communication. Emotional factors pertain to areas such as distractibility or adaptation to change. Support resources include assistance for training to utilize the device from professionals and family members. Assessing the environment helps to gain a perspective on where the user will utilize the technology, and his/her capacity to manage tasks in various surroundings. The SETT model is utilized principally for assessments in educational settings, but can be used in other populations. SETT is an acronym for the **S**tudent, **E**nvironment, **T**asks and **T**ools. The needs of the person and their capabilities are addressed under *students*. The *environment* indicates the venues in which the AT device may be used. *Tasks* are defined as what purposes the student has for the use of AT, and what obstacles may be encountered. *Tools* refers to AT devices and services that can be used to serve the needs of the child. Education Tech Points promotes a process that caters to the individual needs of the person being assessed with an outline of six tech points to guide when AT should be considered for an individual. The tech points include: the referral period, the evaluation process, extended trials, IEP planning, implementation of AT, and periodic review of AT. The Wisconsin Assistive Technology Assessment Model (WATI) provides a compendious resource manual for various assessments including computer access with guides to meet the IEP goals and objectives for the student. Bromley concludes that all of these models have the same focus on assessment and outcomes to utilize the best device in a person's unique environment, and they all accentuate, in some manner, the person, environment, and tasks related to the use of AT. They also emphasize a multidisciplinary, collaborative approach and a functional assessment.

The equivalent document to the Individualized Education Program (IEP) in school-age children that is used for younger children is the Individualized Family Service Plan (ISFP) to engage parents and authorize services. Instituted by a multidisciplinary team, the IFSP specifically addresses the family and its needs and expectations in order to cater to the specialized requirements of the infant or toddler. Section H of the IDEA discusses the family and its needs. AT is used primarily to improve functional capacities identified by the parent and family in early intervention programs. Details culled about the family can be used to establish how the technology will impact the family. Parette (n.d.) and Dublinske (1992) outline modules on assistive technology with young children 2-7 with severe disabilities. Dublinske reported on a project titled "Technology in the Classroom: Applications and Strategies for the Education of Children with Severe Disabilities, Final Report." The purpose of the report was to examine approaches to educate professionals and families in methods to integrate technology into the classroom for 2-7 year olds. One aspect of the project was concerned with technology. There were various modules including a positioning, access, and a mobility module that introduced persons to assessing, selecting, and operating assistive technology. On-site data collection and mailed questionnaires were used to assess the program revealing enhanced comfort with assistive technology, but a need for increased instruction and more detailed modules. Children can be assured a FAPE in the least restrictive environment by better utilizing AT to allow him/her to assimilate.

Trefler (1992) analyzed mobility and access in children with severe disabilities, comparing three models of AT service delivery. There are several questions that must be considered when assessing a child for access. What device will be used for access (e.g., a single or multiple switch, keyboard, or joystick)? What part of the body will be used? What are potential locations for positioning the access device? All of these questions are contingent upon an assessment of the individual's motor, cognitive, and sensory impairments. Trefler outlines the steps involved in choosing an access device for AT including gathering and analyzing information from the child or family, and evaluating the environment and functional abilities of the child. Observation consists of task analysis and noting how the child functions in various environments. The assessment for computer access should incorporate a survey of the child's proficiency when operating an assortment of access devices and recommendations for the most practical and utilitarian device. The technology should be personalized for the child. Furthermore, training should be made available to the child and caregivers in varied contexts while observing for positive effects based on the motor and cognitive behavior of the child when using the device. When implementing an AT device the families and teachers must integrate the technology into the child's educational, home, or community environments. Follow-up is crucial, and frequent monitoring of the efficacy of the access device must continue indefinitely. Sbordone (2001) feels that traditional assessments of brain-injured persons are carried out in artificial environments. Therefore, the assessments are not generalizable to real-world settings. The validity of testing in relatively quiescent settings as opposed to real-world settings that can be more tumultuous and a true depiction of what a person will confront on a daily basis is a legitimate question when looking at practicable solutions for AT. In an artificial setting individuals may perform better, and the real-world problems of distractibility, behavior or emotional problems, inattention, or slowness in processing information may not be as evident.

It is essential to obtain information regarding a person's medical and educational background. It is also imperative to include the family, teachers, and rehabilitation personnel in evaluating a person in the environment in which he/she resides and functions in order to collect empirical data on which to base a decision. There should be a broad-based assessment of persons with TBI for psychomotor problems, language, abstract thinking, reasoning ability, visual-motor abilities, memory, and attention problems. This necessitates an assessment with contributions from a variety of professionals such as occupational therapists, physical therapists, speech pathologists, nurses, educational specialists, and social workers. It is mandatory under federal statutes that in school systems the assessment team must include an educational psychologist trained in neuropsychology who is aware of the problems associated with brain injuries. An assessment may encompass areas such as: intelligence, cognition, organizational skills, sensory and perceptual function, motor and psychomotor function, language (expressive and receptive), visuospatial constructional abilities, memory and learning, sequencing, academic achievement, attention, concentration, alertness, problem solving, judgment, abstract reasoning, and social behavior. One goal of the National Assistive Technology Research Institute (NATRI) at the University of Kentucky is to ascertain methods by which decisions on AT devices are made in the school setting (e.g., the IEPs of special education children). Most states are out of compliance with AT delivery under IDEA according to a 23 year National Council on Disability Study in 2000 called *Back to School on Civil Rights.* NATRI will be studying this and other aspects of AT on a national level. NATRI will be doing this while taking into consideration the quality indicators that have been developed by the national coalition of AT professionals, parents, agencies, providers, consumers, and families involved in the QIAT consortium. The National Center for Education Statistics (2000) reports substandard evaluation services, and plans to study this matter. Data will be collected through interviews, surveys, observation or other interactions. The research questions pertaining to AT assessments will include:

1. How are the functional needs of students for AT identified and considered during IEP meetings?
2. How does the IEP team make decisions about (a) when to refer a student for AT screening or assessment, (b) when to include AT in a student's IEP, (c) whether additional information is needed in order to make AT decisions, and (d) when to conclude that existing AT practices are meeting the student's needs?
3. How are appropriate AT devices selected, designed, or adapted to individual children?
4. How are parents involved in AT decision making?
5. What is the nature of the interactions among parents and professionals on IEP teams where AT is being considered? With other agencies or service providers?

Survey research will be used to determine the specific status of special education teachers and related services personnel and their need for adequate training. Results of this study will be used by those who are responsible for designing both pre-service and in-service training related to AT.

(Lahm et al., 2001).

Assessment for Neurological Impairments

Traumatic brain injury means an "acquired injury" from an external force that can result in deficits in one or several areas such as cognition, language, memory, attention, reasoning, abstract thought, judgment, problem solving, sensory and perceptual abilities, motor abilities, psychosocial behavior, physical function, information processing, and speech. More persons are surviving TBI and it is incumbent upon the school systems, rehabilitative centers, and others involved in AT services to better understand their needs. Nonetheless, there are enduring questions regarding how to proceed with assessments, who will be involved in the assessments, and how to interpret the assessment to meet a person's needs.

TBI differs from a learning disability in that it is an *acquired* disability. TBI consists of more than mere impediments to learning. Traditional neuropsychological measures currently utilized in schools fail to identify impairments. Depending on when the injury occurs, the child will have distinct impairments because the development of the brain occurs in stages. The long term prospect for recovery is dependent upon the severity of the injury and site of the lesion, and recovery may take years. Cognitive impairments associated with TBI should be ascertained. A full assessment by the team (therapists, educators, and psychologists) in various environments should focus on neuropsychological assessment and what services should be rendered related to educational goals (Carter, 2003; Hibbard, Gordon, Martin, Raskin, & Brown, 2001). Hibbard, Gordon, Martin, Raskin, and Brown report barriers to assessing and identifying problems in children with brain injury (specifically TBI). Hence, brain-injured children do not receive the services that they need.

Children may struggle with certain academic subjects when assistance with cognitive deficits in areas such as memory, executive function, processing, and attention is not forthcoming. An appropriate cognitive assessment will identify multiple areas that are problematical, instead of simply looking at intellectual ability, academic ability, and other affective components. Areas addressed with cognitive assessments in four different domains consist of the following:

ATTENTION: Is the student ...

a. Able to concentrate for brief periods?
b. Able to concentrate for longer periods?
c. Able to 'hold onto' and mentally manipulate information?
d. Able to concentrate on more than one task at a time?
e. Able to concentrate better on written, compared to orally presented, information?
f. Accurate when carrying out complex tasks?

INFORMATION PROCESSING SPEED: Is the student ...

a. Accurate but slow in tasks?
b. Accurate in tasks, when time limits are ignored?
c. Penalized on timed tasks due to slowness?

d. Slow to respond verbally to questions or directions?

MEMORY:

a. Can the student retain new information - from one day to the next?

b. Does providing a context improve learning?

c. Are verbal and visual memory skills equally proficient?

d. Does repetition of information increase learning?

e. Does the student attempt to ‘chunk’ or organize similar information to aid recall?

f. Is more information recalled via recognition or through spontaneous recall?

EXECUTIVE FUNCTIONING: Can the student...

a. Think independently?

b. Prioritize the steps in completing a task?

c. Follow through to complete a task logically?

d. Use problem-solving strategies?

e. Organize a task if given structure?

f. Benefit from feedback from others, using feedback to improve performance on tasks?

g. Shift from one task to another?

(Hibbard, Gordon, Martin, Raskin, & Brown, 2001, p.6)

Students also have emotional issues which may manifest themselves in sudden, uncontrollable outbursts by the individual. Frustration and maladaptive behavior may be caused by factors such as over-stimulation in the classroom environment or negative interactions with others. The demands of academics are quick-paced and place multiple demands on the child simultaneously. Often, depending on the age of onset of the brain injury, a person's previous learning may be intact (Hibbard, Gordon, Martin, Raskin, & Brown, 2001).

Neuropsychology uses research into brain function to determine how persons think and act. Educational uses of neuropsychology are becoming increasingly popular for determining why children have difficulty learning. Neuropsychological testing incorporates physical, psychological, and social factors, utilizing standardized assessments, and observation in different environments to determine brain dysfunction or neurological damage (Merz, 1990). The results are not always completely accurate, and the validity of this method of testing has been questioned. While there have been assessments of persons without physical and sensory deficits using neuropsychological testing, there is no proof that the assessments can be generalized to those with disabilities. The examination measures must be exhaustive and compile data from numerous tests to improve validity (Babbage & Leathum, 2000; Merz, 1990). Babbage and Leathum (2000) formulated a retrospective study to see if a comprehensive evaluation incorporating areas such as: cognition, emotion, memory, attention, language, visuoperception and visuoconstruction, motor function, information processing speed, and executive functioning could be administered to persons with disabilities. They categorized certain individuals as hard to assess. Individuals could not be assessed in different realms for a variety of reasons, but those with more than one disability were the least amenable to testing. The researchers concluded that for all intents and purposes, no suitable procedures exist on how to assess persons who have multiple disabilities.

Moreover, there was no way to accommodate for communication or other physical and sensory disabilities.

WATI has developed an assessment of motor abilities related to computer access (Appendix B). This instrument focuses exclusively on motor function in order to assess different modes of access that fall within the abilities of the individual. Tests associated with motor function that are applicable to persons with brain injury have been researched in the literature. Chapin, Deitz, and Jaffe (n.d.) examined tests of motor coordination after TBI in childhood. Prior studies have demonstrated that children with severe TBI are much slower on timed tests of fine motor coordination such as visual motor, tactile spatial tasks, and finger/foot tapping than those with more mild injuries. Using the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) the TBI children were assessed in detail for performance on gross and fine motor tasks, and compared to normal control subjects. Results indicated that most deficits are in gross motor function, but that TBI subjects were lower than normal on the gross and fine motor components. The worst performance in TBI individuals was the speed of movement, especially with eye-hand coordination, a function that is preferentially affected in persons with TBI. Kuhtz-Buschbeck et al. (2003) studied evaluation tools for motor function in children with TBI. Buschbeck used quantitative measures in the lab to determine correlations with subjective clinical tools used by therapists in the field for measures of gait, reach, and grasp. Oftentimes, TBI subjects show a reduction in the precision and speed of movements on quantitative measures. Notwithstanding, these quantitative examinations only explain a small part of a movement, and are too cumbersome to use for many types of movements to award these tests any clinical significance. Also, clinical measures exhibit only a moderate correlation with these lab measures. Therefore, the lab tests do not estimate motor proficiency, nor are they a valid tool to measure clinical changes in motor function. Lab measures may need to be administered in conjunction with more comprehensive field testing. Chae, Labatia, and Yang (2003) evaluated the use of an arm motor test for upper limb motor impairment after a stroke. The Arm Motor Ability Test (AMAT) was used to measure motor function. This was criterion referenced against the Fugl-Myer Assessment (FMA), an evaluation instrument that has been documented as a reliable and valid measure of movements. The principal finding of the study was that the AMAT showed concurrent criterion validity when referenced to the FMA for the assessment of upper extremity motor function after a neurological insult (CVA), especially related to activities of daily living (ADL). However, the test was found to have less validity when measuring more severely impaired persons. There is difficulty in measuring functional movements due the development of synergy patterns and spastic muscles that can cause deficits beyond mere weakness. Smutok et al. (1989) assessed young men with stroke for motor control to see differences in hemispheric lesions. Utilizing measures of motor function such as the ability to isolate movements, the researchers categorized arm movements as having synergy movement only, combined synergy and selected movement, and selective movement only. The researchers also categorized movements using four levels for functional use during activities of daily living (ADL) listed as: (1) normal, independent selective function; (2) assister, or function to assist opposite upper extremity in two-handed activities only; (3) stabilizer, or only functional ability to stabilize objects against table or body; or (4) nonfunctional, or no use during activities. Grouping of the subjects was based on observation during the ADL assessment. Fine motor skills were assessed by simple reaction time to press a button during a light stimulus, pinch and grip strength, rapid alternating movement (tapping finger on table and counting the number of times in 10 seconds), and pegboard tests for manipulation. Similar recovery effects were exhibited by the subjects regardless of hemiplegic side or ipsilateral (same side) deficits present in the groups.

Disabled children have been granted physical access to schools to a greater degree than ever before. However, once they enter school there is considerable diversity in the skills and aptitudes of special needs students. They must be assured that the AT devices assigned to them fit their needs. There is a range of cognitive, physical and sensory disabilities that will be encountered in handicapped individuals. The peripheral devices and software used to access computers can be adapted for physical or cognitive disabilities using various keyboards, switches, keyguards, screen readers, word processing programs, and countless other means to promote access. It is impossible to predict how much or what kind of assistive technology a school district will need, due to the intrinsic variability in the students that need AT services and complex nature of determining the optimal device (Rittner-Heir, 2003).

Essential Assessment Elements

Reed (1999) proposed six steps for implementing effective assistive technology services including: (1) developing a shared vision, (2) assembling an assistive technology leadership team, (3) developing policies, procedures, and forms, (4) having access to AT, (5) providing training, and (6) giving collegial support. A shared vision means fostering respect for AT services in a system that is inclusive and educates team members in order to garner support for a particular vision. A leadership team consists of educators and professionals such as physical, occupational, and speech therapists for training and awareness. Clearly written and detailed policies and procedures are imperative in order to develop an awareness of a need for AT and to implement an assessment. Access refers to the ability to obtain the necessary devices and use them for trial periods. Training and technical support are crucial for the success of AT interventions. Collegial support signifies good communication between those working with AT in the field indicating what is or is not effective for particular individuals.

The National Assistive Technology Research Institute (NATRI) (n.d.) conducted a Delphi study to determine the essential elements of an AT assessment. They listed sixty-three necessary elements for a valid and comprehensive assessment instrument. An array of categories such as medical history, family issues, school assessments, sensory function, communication, cognitive abilities, motor control, psychological factors, tools (AT devices), and environment were enumerated. When assessing an individual for AT, the team should bear in mind that while there is a great deal of individual variability, there are also commonalities between individuals that enable guidelines to be established that outline the most salient areas to be addressed in the assessment. According to NATRI, the assessment process for assistive technology access should be comprised of areas such as cognitive and sensory abilities, positioning, physical access, environment, support, resources, and training. Ultimately, the method for assistive technology access that is finally utilized by the individual must be the easiest, quickest, and most reliable. Cognitive abilities refer to how a person comprehends what they are trying to do and also how they will accomplish a task. Sensory impairments will affect what technology a person can use (i.e., if vision is affected a device that relies on vision will fail).

Appropriate positioning will ensure that the person can readily access a device and use it for its intended purpose. Physical access refers to how a person will use an AT device to accomplish tasks in one way or a variety of ways. The environment has an effect on a person's proficiency with an AT device, and what can be accomplished using the device. The amount of support given to the individual will determine if the available personnel, if properly trained, can help the person utilize the device in the correct manner. A trial period using the device is the only sure way to tell if the device will be effective, allowing for modifications as needed. Training to impart detailed knowledge of the device to the family of the individual being assessed is critical to the success of the trial. There is a need for extended assessments to use with trials to allow enough time for the trial of devices (usually 6-12 weeks). This enables an accurate appraisal of the technology prescribed for the individual (Rachow, n.d.). Rachow illustrates an instrument called the Assistive Technology Extended Assessment Plan by Bowser and Reed (Appendix C).

The Tech Connections Audio Conference (2002) illustrates prototypes of AT assessment models. In their conceptual model of a computer assessment matching the computer to the person they look at three aspects of the process—the human operator, the task, and the context. The HAAT model measures the performance of the person being assessed using assistive technology. The human operator possesses functional capacities. The abilities of the person (intrinsic enablers) related to sensory, cognitive, and effector (motor) capabilities are present in addition to learned skills. The task refers to performing something which can be analyzed pertaining to a work, school, or recreational environment. Finally, the context where the activity must be performed encompassing physical, cultural, and social factors is scrutinized. The HETI model by Roger Smith is an extension of the HAAT model with an in-depth evaluation of the interaction between the assistive technology device and the human. In general, the individual perceives input from the environment, thinks about the information to judge how to respond, and generates a motor response of their choosing. In turn, the assistive technology receives input from the response of the user, processes this input, determines an action, and produces an output that is understood by the person or environment. The HIA model is a further refinement of the HAAT and HETI models to demonstrate the inherent capabilities and learned skills of the human in relation to motor abilities, sensory input, and cognitive processing. The model proposes that as long as a task is within the skills and abilities of a person (even if the person has some type of disability) no AT device is necessary. Only when the requirements of the task surpass the person's ability level, will an AT device be needed in order to rectify this discrepancy. The HIA model matches the skills and abilities of the person who will access the technology with the demands of the technology. The AT will be efficacious only when the person's sensory, motor, and cognitive levels are comparable to the input and output levels of the AT device.

Successful computer access is dependent upon the quality of the match between the user and the technology. No matter how advanced the technology, if the user is not proficient with the device without expending considerable effort, the device will fail to satisfy the goals of the individual and the team. The method of access should be the most straightforward and simplest for the individual (Jasch, 2002; Treviranus, 1994). Treviranus contends that AT access should become an automatic skill. The device is not the ultimate goal of AT. It is a means to an end. If the individual is expending too much effort using the device to perform the task that he/she wants to achieve, then he/she will not possess the energy or reserve to complete the task. For example, if a child has difficulty using a keyboard, then figuring out how to use the keyboard supersedes any type of writing or communicating activity that was the original goal for using the device. The individual must be confident that the device will work in order to become skilled in the use of the access device to improve his/her abilities. Skilled or automatic use is outlined below:

(1) the user can perform the task without reference to or dependence on external prompts, cues, or timing;

(2) the system is predictable and relatively stable;

(3) the system does not require visual or auditory vigilance;

(4) the number and variety of steps required to complete the task are kept to a minimum; and

(5) decisions to be made are kept to a minimum or the decisions to be made are routine, repeated decisions.

"The user should be thinking about what the technology can offer, not the way to access it" (Jasch, 2002, p. 252). The assessment team must ascertain the motor, cognitive, and visual abilities of the child. The team should initiate the assessment by observing the positioning of the individual since optimal movement and attention can only take place when the individual is properly aligned on a stable base. The evaluator should assess for direct selection (e.g., using an adapted keyboard, mouse, switch, etc.) first, which is more efficient than indirect selection (e.g., scanning an onscreen keyboard to choose keys). The positioning of the device will be contingent upon the most consistent part of the body for movement that does not produce fatigue, in which muscle control and strength are adequate (i.e., upper extremity, lower extremity, head, etc.). More than one site may be needed to use the switch for different tasks. If indirect access (e.g., scanning to select a function on the computer) is selected, it must be noted that increased cognitive abilities and concentration will be needed. Different settings for the devices should also be evaluated (e.g., force to activate a switch) (Jasch, 2002). The questions that should be addressed when selecting a switch site are outlined in the following list:

For All Potential Switch Sites:

1. Does the user have sufficient endurance to repeat the motion consecutively?
2. Do reflexes exist that will interfere with the motion the user needs to hit a target?
3. Is tone present that will interfere or enhance the user getting to a target?
4. What is the available range at each site and which is less restricting?
5. Are the available movements the user controls able to hit a target and release in a timely manner?
6. How can the technologist position the switch for optimal activation?

Specific Body Sites

Body parts are listed in order of preference for switch site

Hand function

1. What kind of isolated or gross finger movement is available for a fine

motor switch?

2. Can the user activate a switch if it is in the hand secured with a strap or splint?

3. Can the user control a pointing device?

Arm Placement

4. What kind of arm placement is available for a gross motor switch site?

Head and Neck

5. Does the user still have a visual contact with the device with switch activation?

Lower Extremities

6. Does adequate sensation exist if visual input is not available?

(Jasch, 2002, p. 255)

Persons who are the most severely impaired usually need the devices that are the most complex and high-tech. These are often computerized devices that must be customized for the particular needs of the individual. Certain persons may have little ability to function independently in any capacity without the device (Scherer, 2002). Moreover, the user must have full confidence that the device will match his/her abilities, meet his/her needs, and will be dependable (Barker, 2002). In profoundly disabled persons the effectiveness of AT interventions can be assessed using some of the following criteria: body awareness levels, body language, gross vocalizations, and tolerance to activity; as well as the ability to engage in tasks for longer periods of time

(“Tools for Schools” NYS Office of Advocate for Persons with Disabilities TRAID Project, n.d.). To permit individuals with brain injuries to profit from the utilization of AT, particularly those with profound and multiple impairments, an assessment team should realize multiple factors in its decision making process.

The purpose of the literature review was to examine the contemporary literature pertaining to the assessment of persons for computer access using AT devices. A brief introduction to devices used for computer access reveals the evolution of the technology and the multitude of devices available to disabled individuals. An overview of anatomical structures and physiological functions of the CNS and the relevancy to persons with severe impairments requiring assessment for AT, expressly those persons with severe neurological conditions, reveals the complex nature of nervous system function. The literature regarding the recent advancements in neuroscience portrays the components of motor activities that are needed to access a computer and the various associated sensory, cognitive, and behavioral factors that are involved in operating a device. A description of the pathological processes that are present in individuals with brain injury and the manifestations of these disorders, enables a functional assessment of the capabilities of the person being assessed. The review of social and environmental factors that influence the assessment process exhibits extrinsic factors that affect AT interventions for computer access. An analysis of the current state of AT assessment and facets of the assessment was implemented to portray practices and measures to refine and enhance the evaluative process for AT devices. This was also done to look at various models that have been proposed that characterize the assessment for computer access in various environments for diverse needs in disabled individuals. This information was used to construct elements that should be incorporated into all computer access assessments, especially in persons with severe neurological deficits. This resulted in the development of the categories and the accompanying subcategories that are of potential import to the AT assessment, according computer access to persons with disabilities listed on pages 123 and 124.

CHAPTER III

METHODOLOGY AND DATA COLLECTION

Research Questions

The two research questions that this study answers through the literature review and the Delphi study of the panel of experts are:

1) What criteria should be established as a protocol to examine AT assessment instruments for computer access?

2) What constitutes a comprehensive assessment of a person for computer access using an AT device, especially for those individuals who have severe disabilities as a result of a brain injury, based on criteria developed from a review of the current literature and a panel of experts?

Method and Procedure

The subject matter evaluated focused on assessments for computer access in persons with disabilities, especially assessments applicable to individuals with severe neurological conditions that require a comprehensive evaluation. The end product was a list of criteria that exemplify categories that are essential to the assessment process for computer access that may be utilized in order to critique the evaluation procedure. These criteria have been developed using a review of the extant literature in the disciplines of neuroscience, rehabilitation, and education in order to discern the elements that are essential for the AT assessment instrument.

The criteria were prioritized using a Delphi approach to rank areas according to their importance for inclusion in the AT assessment instrument by a panel of experts. The panel of experts was chosen randomly from persons who were identified as having published in the field (through the literature review), were recognized as possessing a specialized certificate, or were credentialed as an AT practitioner. Although there is no single recognized certification in this field, it was thought that those persons who have made the effort to continue their education or become certified would possess a greater understanding of concepts related to AT assessments for computer access. Moreover, a number of persons who have published in the field are also certified practitioners. Persons who completed one of two prominent AT programs were selected for the study. One of these was the Assistive Technology Applications Certificate Program (ATACP) offered through California State University Northridge (CSUN) which has trained over 1500 individuals since 1997. The other program was offered through the Rehabilitation Engineering and Assistive Technology Society of North America (RESNA) which offers an AT practitioner (ATP) credentialing program. RESNA is notably the premiere AT related organization that has been involved in developing legislation, promoting practice guidelines, and aiding product research and development. RESNA provides a list of certified practitioners; thus, more of these persons were contacted. CSUN does not provide such a list, but the researcher was able to recruit individuals through a posting on a listserv used by individuals who were known to have this certification. There were 33 participants in the first round of the Delphi study and 27 participants in the second (see Figure 7 for the characteristics of the respondents in the first round). The majority of the respondents consisted of persons who are educators and hold either an ATP certification or ATACP certificate.

There were 22 major categories identified in the literature review by the

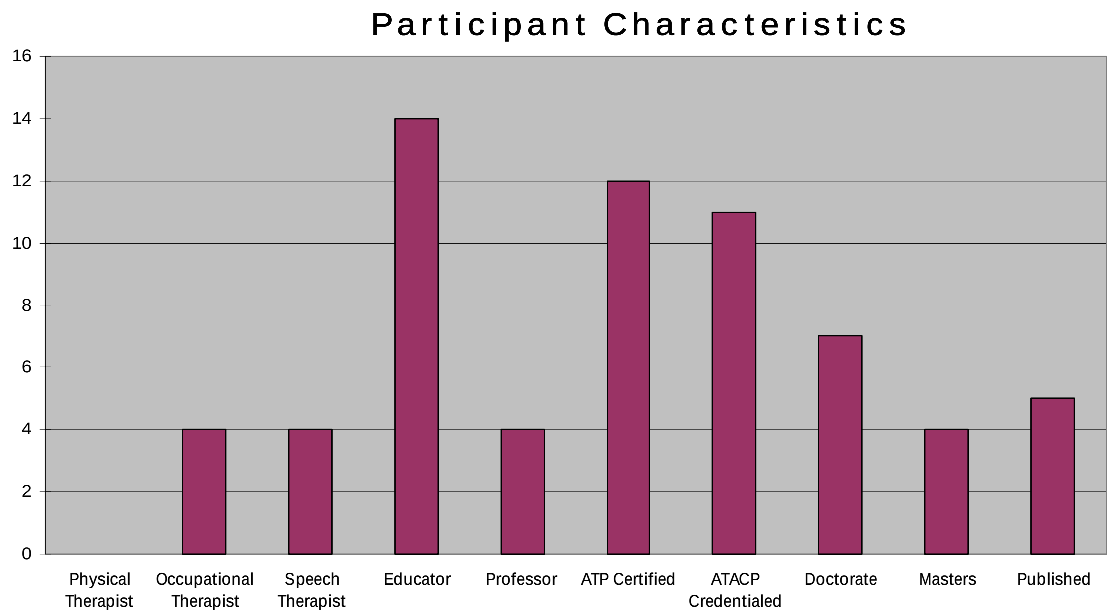

Figure 7: Participant Characteristics

researcher. Detailed descriptions of each category were illustrated on the survey using subcategories, bringing the total to 54 elements. Each of the subcategories was rated using an electronic form utilizing the Delphi format for significance as elements that should be assimilated into a consummate AT assessment. The 22 major categories were listed on the survey as follows:

Category 1: Prior or Current use of Assistive Technology
Category 2: Medical Background
Category 3: Family Background
Category 4: Cultural Factors
Category 5: Educational Background
Category 6: Goals for use of Assistive Technology
Category 7: Communication
Category 8: Cognition

Category 9: Behavior
Category 10: Attention
Category 11: Intelligence
Category 12: Memory
Category 13: Social Adjustment
Category 14: Sensory/Perceptual
Category 15: Vision
Category 16: Auditory
Category 17: Motor Control
Category 18: Range of Movement
Category 19: Posture
Category 20: Team Approach
Category 21: Environment
Category 22: Trials/Devices

The elements (subcategories) in each of the categories were ranked for their essentialness to the AT assessment for computer access as follows:

Very Important
Important
Somewhat Important
Not Important

The study was introduced to the panel of experts through e-mail postings. A letter of introduction containing a link to the Delphi instrument (Appendix D) with instructions on how to complete the initial survey (Appendix E) was transmitted by e-mail to each potential participant. A second survey link was sent via e-mail as a letter (Appendix F) to the 33 individuals who responded to the initial survey during the first iteration. The second survey (Appendix G) was instituted using the Delphi format with the elements that were deemed essential in the first iteration, plus an additional category suggested by one of the experts. The second iteration was implemented in order to obtain a further consensus on the areas that are required for a comprehensive assessment for computer access using AT.

Delphi Approach

The Delphi survey form template was developed by the researcher based on the literature review, and administered through a third party website that will process web-based forms at no cost (Response-O-Matic- http://www.response-o-matic.com/). The third party website is not advertised as a secure site, however it does not reveal data to outside third parties and data are logged for abuse investigations and site administration only. The site does not harvest e-mail addresses, or sell or divulge any private e-mail addresses. The site also does not allow unwanted e-mail solicitations. The results were e-mailed back to the researcher and imported into Excel (Microsoft® Office XP) spreadsheet software. No personal information for the survey was requested from the respondents beyond their name, e-mail address, and credentials (i.e., ATP, ATACP, education, and discipline such as educator or therapist). The survey was returned to the researcher's university WebMail address. No other persons except the researcher and the doctoral committee (if requested) had access to the personal information and e-mail addresses of the respondents to the survey. The data were imported into the Microsoft® Excel Spreadsheet software to be tabulated. The names of the respondents were not published in the write-up of the dissertation. All e-mail records were deleted and hardcopies destroyed upon the completion of the study.

The Delphi approach is a useful method to detect key issues and to gain a consensus regarding various perspectives associated with a particular subject (Carey & Dimmet, 2003; Delphi-History of the Concept, 2003; Wilhelm, 2001). Carey and Dimmit contend that a Delphi approach is ideal for complex problems dealing with diverse populations. Wilhelm (p.6) states that "many social problems are not amenable to solution by positivistic or scientific methods." Wilhelm also advocates the use of the Delphi technique when there is a relative paucity of knowledge or data collection in a particular field. Using the perspicacity of individuals considered as leaders in the field can become a genesis for further study. By involving persons considered accomplished in the field of AT, perspectives on a diversity of issues regarding facets of the AT assessment process are brought into play, aspects that may not otherwise be identifiable (Case, Hasselbring, & Lahm, 2003). The Delphi has proven to be a reliable prediction method using qualitative data (Delphi-History of the Concept, 2003; Ludwig, 1997; Turoff & Hiltz, n.d.). The Delphi technique is amenable to the contemporary use of advanced computer technology utilizing electronic e-mail or chat. Many of the variations in the Delphi technique are also transferable to electronic mediums (Ludwig, 1997; Turoff & Hiltz, n.d). Use of 15-20 persons is generally appropriate for a representative sampling if strict criteria are used to select a panel of experts. Typically, about three rounds utilizing a Delphi instrument is desirable over a period of weeks in order to gain a consensus, although a convergence by the panelists on the issue may occur in more or less attempts. Since there are many variations to the Delphi approach, researchers typically are utilizing what is termed a "Modified Delphi Technique" (Ludwig, 1997). Nevertheless, Ludwig articulates three general components of this approach. The technique is: (1) focused on the future (i.e., planning or deciding a new course of action), (2) emphasizes data collection in order to garner a consensus, and (3) utilizes a panel of experts. The data assembled regarding the importance of various categories associated with AT assessment instruments was based on the feedback from a panel of experts. The responses and attendant comments were recorded in order to develop a valid set of criterion to facilitate an analysis of the content of AT access assessment instruments (Turoff & Hiltz, n.d)..

Pilot Study

A pilot of the survey form was instituted by the researcher to obtain feedback pertaining to the content and clarity of the survey form. The pilot of the study sought feedback from five individuals including a physical therapist, an occupational therapist, a speech therapist (all of whom completed the CSUN certificate program for AT practitioners), a special education professor (dissertation committee member) involved in assistive technology, and another special education professor who has published in the field of AT. These persons were not involved in the Delphi process using the survey, but were asked to contribute to the development of the final survey instrument. Based on the counsel received from the individuals who participated in the pilot study, several alterations were made to the survey instrument. These modifications consisted of: giving more explicit directions to the potential survey respondents, designing clearer distinctions between items on the survey form, using more conventional language and terms for improved comprehension, defining terms, and reducing potential bias in the letter of introduction to the initial survey form. It was also suggested that the survey was somewhat lengthy, so it was condensed into the 54 elements listed under the 22 categories that you see enumerated above.

One of the critiques was received after that particular individual had seen some preliminary revisions that were made to the instrument. This individual did not appear to understand the exact purpose of the pilot survey. Instead, this individual answered the survey questions and offered a few general comments. Consequently, this person's responses were not included in the survey data. No further modifications were made to the survey instrument. Four of the five individuals from whom feedback was requested responded to the pilot of the survey.

First Iteration

The first survey (Appendix E) was e-mailed to 83 individuals to summon a representative population of respondents for the survey who were researchers or practitioners, using the aforementioned criteria. The names of individuals who have published in the discipline of AT for computer access were obtained from the literature review. Practitioners in the field of AT were recruited for the study from a listing on the RESNA Web site for ATP certified individuals. A solicitation was also placed on the listserv for the ATACP offered through CSUN.

The results of the survey for each individual were exported to Microsoft® Excel Spreadsheet software and were tabulated and combined to determine percentages of rankings (i.e., “very important”, “important”, “somewhat important”, or “not important”) for each element. The comments were also exported with the ranking data to the spreadsheet to be analyzed and categorized. Out of the 83 persons solicited for the study, there were 33 responses resulting in a response rate of 40%. A response rate of 30%-50% is generally considered satisfactory for an initial survey that is constructed and introduced to the potential respondents in an acceptable manner. Furthermore, in this study, the respondents as a whole did not differ significantly from the non-respondents, leading one to infer a representative sampling of the target population (Gay & Airasian; 2000).

The survey respondents were either certified as AT practitioners through RESNA, persons who have published in the field, persons who have completed the ATACP offered through CSUN, or any combination of the aforementioned selection criteria. The entire process to elicit responses for the initial round of the survey took approximately five weeks. The protractedness of the initial iteration was due in part to a delay in contacting the CSUN certified participants.

Subcategories that did not have a response were not counted in the percentages. The benchmark formulated by the researcher that 80% of the participants respond "very important" or "important" in order to include a particular subcategory in the second round of the Delphi study was utilized. However, this benchmark was not adhered to as the sole criteria for retaining certain elements in the first round. There were nine subcategories under 80%, and 7 of these were eliminated including: *Economic Resources* (59%), *Academic Testing* (70%), *Formal Education* (73%), *Formal Measures of Intelligence* (70%), *Basic Social Skills* (67%), *General Computer Competencies* (70%), and *Affordability* (70%). (See Table H-1 in Appendix H). Many had "not important" responses or few "very important" responses. Subcategories were also evaluated using the overall percentage, distribution of responses, and the comments made by the respondents. For example, if a category scored above 75% for “very important” or “important” responses it was considered for inclusion in the second round if there were a limited number of “somewhat important” or “not important” responses, and few negative comments. Two additional subcategories were eliminated upon further reflection based on comments offered by the respondents. These two categories were *Input Devices* and *Output Devices*. Even though both of these subcategories received high scores of 100% and 97% respectively, it was thought that it is intuitive that these areas be included in any assessment for computer access since these are the types of AT devices being chosen in the assessment process, and one or more of these devices will be the outcome of the assessment for computer access. Another outcome of the assessment process is software that promotes access, although this subcategory was not listed on the survey instrument. The two categories that were less than the benchmark of 80% and were retained for the second iteration consisted of *Cultural Factors* (75%) and *Semantic Memory* (76%). Cultural factors was the only item in its category, and garnered a number of "very important" responses, thus it was preserved for the second iteration. Moreover, both of these subcategories approached 80%, and did not receive any "not important" responses. Comments elicited in these areas were also taken into consideration, as was the information acquired from the literature review. An additional subcategory was added under category 22—*Follow-Up*. This was based on a recommendation proffered by one of the respondents.

Second Iteration

Another letter was sent to the participants (Appendix F) with a link to the second survey. The link to the revised electronic survey (Appendix G) was e-mailed to the 33 respondents who replied on the first iteration in order to gain a further convergence on the elements that should be included in an assessment for computer access. The participants were given approximately two weeks to respond. The second survey was modified and consisted of the 46 subcategories that were determined as necessary for the assessment process using the ratings and comments by the individuals responding to the initial survey. There were 27 respondents to the second survey out of the 33 survey links e-mailed to the participants, resulting in a response rate of 82% on the second iteration.

This represents a rather small rate of attrition between rounds, although the researcher did not secure data to determine an acceptable range for attrition in a Delphi study per se. Generally, follow-up surveys seek to increase the response rate by at least 20%, with a rate of 10% or less indicative that the follow-up survey was not advantageous (Gay & Airasian, 2000). Although this was a Delphi study utilizing a longitudinal method of subsequent iterations within a relatively short time span, the increase of over 40% on the second survey would appear to be within acceptable limits.

Some Delphi studies furnish aggregated responses from the prior rounds when initiating subsequent iterations. This may be beneficial in some cases. Aggregated responses obtained in the first round were not included in the second round because of the potential for compelling subjects to respond differently based on the results. Posting the results from the first survey may induce a ”bandwagon effect”, introduce bias, or contribute to attrition of participants from the study if he/she observes that his/her response is part of the minority view, (i.e., the response is conspicuously different from the majority). Many researchers display the results of each round to gain a further consensus (or to look at responses in a certain range and try to improve on these). A researcher may also post the results of preceding rounds to secure an explanation for why individuals may disagree regarding a particular area (Love, 1997). The initial iteration in this study garnered a fairly strong consensus in many of the areas.

The second survey appeared to gain additional convergence on the issue of computer access assessments, and evoke responses to ascertain which elements were more vital to a comprehensive assessment for computer access. The results for each survey were exported to Microsoft® Excel spreadsheet software, combined, and percentages were tabulated for each subcategory in the second round. The comments of the respondents were also exported to the spreadsheet to be analyzed and categorized.

Out of the 46 subcategories, 39 received scores of 80% or above to warrant inclusion in the assessment for computer access using AT. Subcategories that were not marked were considered non-responses. Those subcategories in which two separate ratings were selected were also considered non-responses if the expert panelist did not clarify their intended response after requests were sent by the researcher via e-mail. The 7 categories that were eliminated were: *Cultural Values* (74%), *Expressive Communication* (78%), *Semantic Memory* (70%), *Observational Analysis* (Socialization) (67%), *Sensory Input* (78%), *Auditory* Exam (74%), *Scoliosis or Kyphosis* (78%). The 39 categories that were retained subsequent to the second survey were: *Prior Utilization* (92%), *Health Exam* (85%), *Support Resources* (Family) (96%), *Supportiveness of School Staff* (93%), *Assessment Team Goals* (100%), *Individual/Family Goals* (92%), *Language Disorders* (88%), *Receptive Capabilities* (*85%*), *Cognitive Function* (89%), *Observations of Impairments* (Cognition) (89%), *Affective Characteristics* (88%), *General Personality Traits* (85%), *Disordered Thought Processes* (96%), *Attentiveness* (96%), *Observation of Performance* (Intellectual) (85%), *Declarative and Procedural Memory* (81%), *Perceptual Input* (85%), *Visual Acuity* (81%), *Visual Perception* (93%), *Auditory Processing* (85%), *Muscle Strength* (89%), *Muscle Endurance* (89%), *Coordination or Movement Quality* (96%), *Muscle Tone* (89%), *Functional Mobility* (85%), *Fine Motor Coordination* (96%), *Motor Responses or Initiation* (96%). *Range of Motion* (85%), *Postural Stability* (93%), *Postural Support* (85%), *Collaboration* (96%), *Qualified Team Members* (100%), *Environmental Assessment* (100%), *Trials in*

Environment (100%), *Device Flexibility* (96%), *Compatibility* (96%), *Technical Support* (96%), *Family or Support Personnel* (100%), and *Follow-up* (100%) (See Table I-1in Appendix I). Since the second survey sought to gain further consensus by the experts on the areas that are truly essential to the AT assessment, the benchmark of 80% was adhered to as the criterion for inclusion based on the Delphi results. However, some of the categories approximated the 80% benchmark, and garnered comments in support of the elements. Therefore, the researcher reflected further on these areas in the conclusions of the study based on the literature review and the observations made by the expert panelists.

CHAPTER IV

DATA ANALYSIS

Results of the Delphi Study

Only those items ranked as significant to the assessment process through a consensus (a rating of "very important" or "important" by 80% of the respondents was the benchmark set by the researcher for each subcategory ranked by the panel of experts) were listed as important criteria for an assessment instrument at the end of the Delphi study. Inferences and conclusions from the data were based upon the information collected regarding elements that should be incorporated into an AT assessment, and included in a valid and comprehensive instrument. The information garnered from the literature review was also scrutinized and used in the data analysis.

The data were categorized based on the concordance reached by the panel of experts regarding which of the various elements of the AT assessment for computer access listed on the Delphi study instrument were important for determining the correct device for severely involved individuals, subsequent to the two iterations of the survey forms. The data were then analyzed qualitatively with regard to what areas assessment instruments should incorporate and the rationale behind these deductions. A list of recommendations was generated enumerating general concepts on what elements should constitute a valid and comprehensive AT assessment for computer access. The data were interpreted in order to formulate conclusions and suggestions for improvements in assessments relating to computer access for the disabled, and what areas should be integrated into a valid assessment of AT needs in persons with severe neurological disorders. Limitations of the study were discussed and a concluding statement was proffered with proposals for refining the assessment process and ideas for further research. Results for the initial iteration are shown in Table H-1 (Appendix H). The final results obtained from the second round of the survey are listed in the Table I-1 in (Appendix I).

First Iteration

For category 1 *Prior or Current Use of Assistive Technology*, there was one subcategory, *Prior Utilization* of AT. The results were strongly in favor of this subcategory being included in an assessment instrument. This area was awarded a rating of “very important” or “important” by 89% of the participants on the first iteration. The high percentage of respondents rating this area as “very important” reveals that prior utilization is considered meaningful to the assessment process, and also indicates a strong consensus for inclusion. Conversely, if the majority of respondents reacted negatively to the category (i.e., “not important”) there is concordance exhibited by the panelists that a particular area is not essential to the assessment process. If the responses are more evenly distributed ranging from very “important” to “not important”, there is less of a consensus in either direction. There were several comments by the respondents referring to category 1. Three references were made pertaining to the use of information gained from the prior utilization of AT devices to determine what has or has not been successful in the past. This can be done in order to gain information for the assessment and eliminate the possibly of repeating the same mistakes. Similarly, another panelist stated that there needs to be detailed data available regarding interventions that have been tried beforehand, in order to make informed decisions on the current needs of the individual, not simply to document “tried switch x.” Additionally, one of the respondents stated that information regarding the prior use of AT may reveal a person’s “competencies, interests, and motivation.” Another suggestion was that while examining the individual, prior AT use should be considered, but should not be the primary justification or rationale for selecting a device. One of the panelists recommended that “continuity” in the use of AT in the home and at school is one factor that should be assessed. A comment was also proffered which expressed the opinion that not only should this area be included to ascertain why AT has not been successful, but also may divulge information on why a person was referred for an assessment. One of the other respondents remarked on a prominent issue all to commonplace in AT prescription, abandonment. Data regarding the prior failures may prevent a recurrent failure during device trials. There was one individual who stressed that this area of the assessment is compulsory due to the high level of turnover in AT team members. A respondent stated that the time frame since the prior utilization should be taken into account when looking at other options. An individual can be trained to use a device regardless of prior use or age, so this area may not be that important, although prior AT use may be of some benefit according to another respondent. One of the individuals working in Mexico stated that AT is an area that is unknown making prior utilization less of a factor.

Respondents were a bit more equivocal when considering the significance of category number 2, *Medical Background*. As with category one there was only one subcategory, *Health Exam*, that pertained to the information in the medical record of the individual. For this subcategory, 85% of the individuals responded “very important” or “important” (14 “very important”, 14 “important”, and 5 “somewhat important”) on the first iteration. This demonstrates a moderate consensus that medical background is needed for an assessment. The consensus would increase with a greater number of “very important” responses.   However, the results were substantial enough to warrant the inclusion of medical background in the assessment. Therefore, a health exam should be reviewed for an assessment according the majority of the panel of experts in round one of the study. A panelist remarked that the medical background is only necessary if it is germane to the individual’s functional abilities. Similarly, a suggestion by another respondent was that any functional limitations of the individual must be obtained from the AT evaluation regardless of the medical background. One comment was given stating that the medical exam is useful for determining the extent that a person will be able to participate in learning how to use a device, and the level of training that may be needed. Even though the past medical history should be obtained, caution must be exercised that the diagnosis is not used to classify the individual as low functioning according to another respondent. One other participant voiced the comment that the medical condition of the individual must be explored, and the assessment team must be aware if the medical condition is progressive or non-progressive. A panelist expanded on that theme, declaring that a degenerative condition will affect long-term use of an AT device. One of the experts felt that it is also important to know what types of medications the person has been prescribed, since there may be effects from these medications such as decreased alertness or a change in muscle tone. One of the respondents believed that you may get information from families, so you must “consider the source” so to speak, since the assessment team may have difficulty procuring data on the past medical history from physician records.

Family Background was considered in category 3 and included two subcategories, *Economic Resources* and *Support Resources*. *Support Resources*, with 97% of the respondents rating it as “very important” or “important” was deemed necessary with a high level of agreement between individuals comprising the panel of experts. In contrast, the respondents did not feel that the subcategory *Economic Resources* was needed for an assessment for computer access using AT. This element received a score of 59% of respondents rating it as “very important” or “important” on the first iteration. A panelist stated that this category is not needed for an assessment to decide what device a person needs, but is important to the implementation of AT services. Another commented that they have observed that there is less chance of success when a person lacks support resources. Support is important at “all levels” for a person to become proficient using a device, or if modifications are required in the future according to another panelist. The problem of abandonment is closely linked to this category as attested to by another of the respondents. She stated that, “If there is no ongoing support available, the AT options are not maintained and end up in the proverbial closet.”

Category number 4 was termed *Cultural Factors* related to the assessment process. This category encompassed only one subcategory, *Cultural Values* pertaining to the individual and those around him/her. This category was not felt to be that consequential to the assessment process by a slight margin, as evidenced by 75% of the respondents rating it as “very important” or “important” on the first iteration. However, since there was only one subcategory in this area, and it was not rejected by a significant margin, it was retained for the second iteration. Furthermore, many of the comments evinced support for this element. A panelist asserted that this element is one of the most neglected in AT assessments. If there is rejection based on cultural factors, implementation may be a problem that will hinder use of the device according to another panelist. This category is important because the family must see the device as “necessary” and culture can affect the utilization of a device, such as a communication device, according to some of the respondents. One felt that this area was important because it deals with the psychosocial aspects of AT prescription, and cultural issues will have an influence on the success of the device. A panelist believed that it was imperative that the family be supportive, and the manner in which information about the device is disclosed by the AT team to the individual and their family is vital. Another of the study participants felt that culture affects the range of devices that can be chosen. Two respondents from Mexico who have trained in the U.S. commented that there is not a disability culture in Mexico. One of the panelists from Mexico depicted a culture that discriminates against and rejects those with disabilities, and the need for a culture that realizes that these members of society can contribute and become productive utilizing technology.

Educational Background was the term used to describe category 5. There were three subcategories listed under category 5 consisting of *Formal Education, Academic Testing,* and *Supportiveness of School Staff. Formal Education* was not found to be crucial to the assessment process by the panel of experts with a score of 73% on the first iteration for answers that describe this subcategory as “very important” or “important.” This area was not retained for the second iteration. Although there was only a slightly lower percentage of “very important” or “important” responses than the benchmark of 80%, many of the respondents did not endorse this area for inclusion in the assessment when the comments were examined. There was even less support for the meaningfulness of *Academic Testing* to the assessment process. It did not equal the significance that was assigned to the subcategory of formal education shown by a score of 70% on the first round. Therefore this subcategory was not judged as necessary for an assessment. *Supportiveness of School Staff* was designated as essential to the assessment process indicated by a score of 97% on the first iteration for the percentage of persons who rated the category as “very important” or “important.” There was also a high level of consensus with 23 respondents rating this subcategory as “very important.” A comment extended by one of the expert panel members was that acquiring the educational history to gain knowledge regarding the educational background of the individual was conducive to discerning the correct information for this category. Statements about whether or not the school endorses the use of the AT device will determine the success of the device were proffered by a number of respondents. Two participants in the survey believed the extent to which persons in the school advocate the use of technology will be a determining factor for whether or not the device is used. A statement by one of the panelists referred to the significance of this category to the assessment, particularly in a school setting where there may be a high level of staff turnover. There was another expert who stressed that AT devices are funded for educational reasons, and the assessments of this area may determine who pays for a device. This category was designated as an area for implementation and not assessment by one of the respondents, similar to a comment made for category 3. A panelist who did not subscribe to the importance of formal testing for AT use cited the bias and problematic nature of academic testing. A comment was also made that oftentimes the primary purpose of the device is to enhance cognition.

Category 6 pertained to *Goals for Use of Assistive Technology*. Included under this heading were two subcategories denoted as *Individual/Family Goals* and *Assessment Team Goals.*   Both of these subcategories were found to be essential for the assessment of disabled individuals for computer access with a significant percentage of the replies characterized as "very important" or "important." There was a score of 94% on the first iteration for *Individual/Family Goals*.   For the subcategory *Assessment Team Goals*, the importance to the assessment process was evidenced by a value of 100% on the first round of survey. The overwhelming number of responses citing "very important" (25 for each subcategory) denotes a strong consensus by the participants in this area. If the goal(s) of the individual are not taken into account he/she will not utilize the device according to one of the panelists. A panelist responding to the survey advised that "motivation is tied to use," stressing the importance of meaningful goals. Also, if credence is not given to both parental and school goals, the device may not be considered useful according to another. Moreover, a member of the expert panel remarked that the goals for the individual and family are often in marked contrast to the goals of the team. A respondent commented that there may be more emphasis on the goals of the AT team if the AT device is to be used for educational purposes. An expert stated that an AT device may not only help in meeting educational goals, but may assist in the socialization and function in environments outside of the school. Additionally, one of the other survey respondents observed that goals change as the person matures and must be reassessed. Likewise, one participant commented that if goals are not related to function or are not attainable, any incentive to continue using the device is greatly diminished.

Category 7 was given the title *Communication*. There were three subcategories listed under *Communication* including *Expressive Communication, Language Disorders,* and *Receptive Capabilities*. Both expressive and receptive communication were determined by the experts as being critical to the assessment process with scores of 97% on the first iteration of the survey by respondents who rated the subcategories as “very important” or “important.” The other subcategory under *Communication, Language Disorders*, was also believed to be elemental to the assessment process, though slightly less so than the other subcategories. *Language Disorders* attained a score of 94% in the first round, but there were fewer responses rating this subcategory as “very important.” However, all of these subcategories demonstrated a fairly strong consensus with more than twice as many “very important” responses. There was a comment made that for expressive communication to occur, there is the issue of compatibility between the person and the device. Another respondent felt that receptive skills were probably more critical to successful utilization of AT, but that modes to enhance expressive communication should be attempted through various means (e.g., signing, PECS, etc.). One of the panelists identified a matter of contention between the AT assessment team and parents of severely involved children who have unrealistic expectations regarding his/her child’s ability to use AT devices. Furthermore, according to this panelist, communication is a prerequisite for the comprehension of cause and effect, even to perform relatively unsophisticated tasks. Another expert espoused the view that communication is a “human right” and should be attempted no matter how severely impaired the person happens to be. An expert believed that this category is essential only when communication is the goal of the device, while another disagreed, reporting that this category is crucial, and that we need to realize modes of communication that are different from our own. There was a comment made that responses by disabled individuals need to be understood by those without disabilities, although this requires more study. There is a need to relate function to expressive and receptive communication to implement the correct interventions.

Category 8 was concerned with *Cognition* with two subcategories designated as *Cognitive Function* and *Observation of Impairments*. Both of these subcategories were rated as elemental to the assessment for computer access. *Cognitive Function* attained a score of 97%, and *Observation of Impairments* showed a similar percentage (100%) for “very important” and “important” responses by the participants in round one of the Delphi study. Notwithstanding, there was a lower consensus than many of the other areas. Comments included one that noted that the cognitive status of the person will significantly impact the decision to use high-tech, low-tech, or any other device. There is another characteristic affecting this area according to the one of the experts—the stability of an individual’s cognitive state—and whether it may be expected to deteriorate or improve. One of the respondents observed that these subcategories are also important relative to the environment in which the patient functions, while another remarked on the ubiquity of cognition for task performance. The statement was also made that addressing function that is linked to cognitive level with the “design features” of a device is an aspect that must be considered when attempting to improve abilities such as communication. An expert mentions that oftentimes the evaluator is not familiar with the person, and does not wait for a reply from the individual that they are assessing, when in fact the person has slow information processing abilities, and may still be able to respond appropriately. Children’s parents desire the use of a device, even when the child is severely impaired and cannot demonstrate an understanding of cause and effect, revealing the devastating effects of impaired cognition on the child's ability according to another respondent.

Category 9 was labeled as *Behavior* with three subcategories designated as *Affective Characteristics, General Personality Traits,* and *Disordered Thought Processes*. These subcategories should all be included in the assessment instrument according to the respondents, although there was not a particularly robust consensus between the expert panelists. A score of 94% for *Affective Characteristics* for the percentage of "very important" or "important" ratings was observed in the first round. For *General Personality Traits* the score was a bit lower at 89% for the first iteration. The subcategory of *Disordered Thought Processes* was comparable to *Affective Characteristics* with a score of 94% for the first iteration. These categories are more relevant when there is the potential to use more complex technology (e.g., voice recognition), according to one of the experts. Another comment referred to the necessity to look at all of these areas or the purpose of the AT device may not be realized. This area is important in that it is linked to self-esteem and socialization according to one respondent. Another felt that behavior was not that critical to the assessment, but she would not use expensive devices with a "violent" client. AT can lessen inappropriate or disruptive behaviors, but should not be used to "rule out" these behaviors, which should be attended to according to one of the panelists. Still another advised that it is extremely problematical when attempting to instruct these individuals on how to use the device because they can be so emotionally labile. This area was also thought to be more applicable for implementation of the device rather than assessment by one of the experts.

Category 10 was *Attention*, and contained only one subcategory designated as *Attentiveness*. This was rated as a necessary area to assess by the panel of experts. This was demonstrated by a score of 97% of experts rating this subcategory as “very important” or “important” on the first survey. It was apparent that this subcategory was seen as valuable to the evaluation process, but only moderately so compared to some of the other categories with regard “very important” responses. Evaluation of this element was also thought to be more essential when using complex technology. A panelist believed that attention is critical to all tasks the individual may be trying to perform, analogous to the comments made concerning behavior. There was a comment made by one of the respondents that it is particularly important for persons with disabilities—more so than others without impairments—to filter out extraneous information. This can make a difference in accomplishing a task or the inability to complete a task. Another panelist expressed the sentiment that attention is critical to any carryover allowing continued use of the AT device. Attention will also influence the trial phase when training on the device. One of the panelists who deals mainly with Alternative Augmentative Communication (AAC) devices felt that depending on the type of system that is utilized for communication purposes, attention is an important concern in the AT assessment for computer access.

In category 11, *Intelligence* was an area that encompassed two subcategories, *Formal Measures of Intelligence* and *Observation of Performance*. Only *Observation of Performance* was viewed as essential to the assessment instrument for computer access using AT attaining a rating of 97% on the first iteration for respondents choosing this element as “very important” or “important” to an assessment for computer access, yet the consensus was somewhat low with 14 “very important” responses. *Formal Measures* of intelligence achieved a score of 70% for the first round of the survey. There were comments attributed to this category describing how a functional evaluation is needed to observe factors associated with intelligence. Another participant responded that the entire level of performance of the individual must be obtained to ensure success with a device. This is an area that is important when attempting to match the device to the individual and it was mentioned that cognition will influence the ability to implement or sustain the use of a device in a variety of settings (i.e., generalization of functionality to diverse settings). One of the respondents stated that the assessor must look at the individual’s intellect in a particular domain to assess the ability to reason. A panelist noted that in her experience, IQ scores are not good independent measures of a client’s abilities.

Category 12 pertained to *Memory*, with two subcategories, *Declarative and Procedural Memory* and *Semantic Memory*. *Semantic Memory* was determined by the panel of experts as not particularly important by a fairly narrow margin, with 76% of the panelists in the first round responding that this subcategory was “very important” or “important.” Yet, this subcategory was kept for the second iteration due to its approximation of the benchmark score of 80%, and the fact that there were no ratings designated as “not important” for *Semantic Memory*. Moreover, many of the comments appeared to support the importance of memory to the assessment. The subcategory related to *Declarative and Procedural Memory* was rated as essential to the assessment instrument. The percentage score was moderately high, with 89% of the respondents citing this item as “very important” or “important” on the first iteration, yet there were less “very important” responses (13). It was the opinion of one expert that procedural memory was more critical to the use of AT. The comment was reiterated that this area is more likely to be important to the assessment when the device being prescribed is complex. One of the survey respondents perceived memory as being critical for retaining the ability to become more independent through the recall of events and skills that they have executed in the past. Still another felt that this area is necessary to assessing the individual, but that you are able to gain much of this information from a relatively brief time working with the client, and a "formal" assessment may not be needed. A comment used for other categories was repeated (i.e., the selection of a device should always be related to function). Additionally, this category was not necessary for all tasks according to another respondent.

Category 13 looked at *Social Adjustment*, encompassing two subcategories, *Observational Analysis* and *Basic Social Skills*. *Observational Analysis* of social adjustment was ranked as not essential to the assessment instrument by a slight margin, but approached the cutoff of 80% with 74% of respondents rating it as "very important" or "important" on the first survey. Thus, it was included in the second round. Also, the comments by the expert panel supported this subcategory. *Basic Social Skills* was not found to be an important element of the assessment by the panel. The percentage of respondents rating this subcategory as "very important" or "important" was 67% for the first iteration. Socially appropriate behavior is important to "mainstreaming" individuals according the one of the respondents. Again this area is task dependent according to another respondent. A panelist portrayed a situation where one is assessing to improve communication using a device, and the importance of knowing how the individual interacts with others in environments where the device will be used.

Category 14 deals with *Sensory/ Perceptual* measures involving two subcategories, *Perceptual Input* and *Sensory Input*. Both were found to be decidedly important to the assessment process, particularly *Perceptual Input. Perceptual Input* scored 97% and *Sensory Input* 94% for “very important” or “important” ratings for the assessment in the first round, with a moderate consensus (perceptual input received more “very important” responses). Comments similar to previous categories that this area was important relative to matching of the device to the person and is needed only for particular tasks were repeated. An expert panelist working in a school for the blind stated that this area is the one that would be assessed prior to any others. One of the respondents related this subcategory to communication, observing that this category is necessary for finding the method used to allow communication.

Category 15 was labeled *Vision*. There were two subcategories consisting of *Visual Acuity* and *Visual Perception*. Both of these subcategories were recommended by the panel of experts for inclusion in the assessment instrument. *Visual Acuity* and *Visual Perception* were both judged as “very important” or “important” by 94% of the respondents with a moderate consensus. Comments included the previous comments that the area evaluated must be used to match the device and that this is an area that is only necessary to assess for specific tasks. One of the experts stated that frequently visual impairments are the justification for an AT assessment to be performed in the first place. A respondent returned to the concept of function, where the device layout and the choice of what features to use are related to vision. Another panelist remarked that obtaining access to a visual exam is necessary, and if there is no access, an exam should be administered. A survey respondent thought that this category should be used to ascertain that the correct device is used, or eliminate solutions that will not work. If the individual is not an effective communicator, this area is very difficult to assess according to another panelist.

Category 16 dealt with the *Auditory* components related to the assessment for computer access. There were two subcategories developed for this category consisting of *Auditory Exam* and *Auditory Processing*. These were both recommended by the panel for inclusion in the assessment for computer access. Both of the categories were thought to be “very important” or “important” to the assessment by 91% of the respondents. The number of “very important” or “important” ratings of these two elements was approximately even for each subcategory. The same comment given for some of the other categories was expressed (i.e., data from the category should be used to set up a match for the device). It was emphasized by one of the study participants that vision and hearing abilities are, without exception, crucial to choosing an AT intervention. The same comment that had been issued previously for category 15 was repeated for this category; that often this is a reason that a person is referred for an assessment. The comment that this area is task dependent was also reiterated by one of the experts. A panelist remarked that this area is one of the easiest by which to evoke a response in an individual being assessed.

Category 17 pertained to *Motor Control*, and encompassed seven subcategories. All of these categories were deemed essential to the assessment process, although some more explicitly than others. Percentages for selecting “very important” or “important” were high for all categories. Scores were as follows for the first iteration: *Muscle Strength* 91%, *Muscle Endurance* 94%, *Coordination or Movement Quality* 97%, *Muscle*

Tone 97%, *Functional Mobility* 90%, *Fine Motor Coordination* 97%, and *Motor Responses* or *Initiation* 100%. All were consistently rated as "very important" or "important" with a fairly even distribution among all categories with a moderate consensus, except for a strong consensus for *Fine Motor Coordination*. The comment espoused by one of the respondents was that once again, that the feature you are assessing needs to lead to matching the individual to the device. There must be a thorough exam of this area for an extended period according to another of the experts. One of the panelists noted that this area is important only to the target task, and that the category as listed on the survey contained an overabundance of "technical jargon." Another expert felt that this area is "directly related to device/system choices, design…"

Category 18 was denoted as *Range of Movement*, with only one subcategory described as *Range of Motion*. This area was also thought to be important to the assessment instrument by the panel of experts with a score of 89% on the initial survey designating it as "very important" or "important" to the assessment with a moderate consensus. This area was also considered crucial to matching the device, a response articulated for several of the other categories. A panelist remarked that you cannot contemplate what device to use without first exploring this area. One of the comments conferred was that it is advisable to measure range of motion in the plane of the computer interface. A respondent remarked that there is usually some method by which the AT device can be adapted for someone with restricted range of motion.

Category 19, which pertains to *Posture*, contains three subcategories, *Scoliosis or Kyphosis*, *Postural Stability*, and *Postural Support*. All of these areas met the criteria for inclusion in the assessment (with a moderate consensus), although the subcategory for

Scoliosis or Kyphosis was not rated as "very important" by a significant number of the panel in the first iteration of the Delphi study. The subcategory *Scoliosis or Kyphosis* received a score of 84% on the first survey for rating this area as "very important" or "important." *Postural Stability* garnered a score of 94% and *Postural Support* a score of 91% as "very important" or "important" to the assessment. Two of the panelists offered the comment that normally this area has already been accommodated by a seating system, and is a separate issue. Another comment was the same one used with a number of other elements that this category is important related to matching of person to the device. One of the panelists observed that posture is so critical for placement of the device for access, that there is no reason to perform an assessment if the person is going to receive a new positioning system. Two panelists noted that this category is necessary for accommodations for computer access to be effective. There was also a panelist who remarked that if an individual is improperly positioned he/she will struggle when attempting to perform any task. Positioning affects many things (i.e., visual field). One of the respondents asserted that this area is not one in which she has more that a superficial knowledge, and that she would consult a specialist if she noted a problem.

Category 20 was identified as a *Team Approach* and was made up of two subcategories, *Collaboration* and the presence of *Qualified Team Members*. Both of these subcategories were found to be extremely necessary to the assessment process with the majority of the experts rating these as "very important." The percentage selecting "very important" or "important" for *Collaboration* and *Qualified Team Members* was 100% on the first iteration. There was a strong consensus in favor of inclusion of this element in the assessment for computer access, with the vast majority of the respondents rating these subcategories as "very important." One panelist believed that both subcategories (*Qualified Team Members and Collaboration*) were equally necessary for the assessment to work. According to another expert, communication is crucial among all of the members of the team. Another believed that this area is critical to the success of the assessment since we can not all be "experts" in all facets of an assessment for AT. There can be significant problems with devices when a person with little or no expertise makes the decision in favor of a device or data for the assessment are erroneous. Another articulated that the team needs to be trained in AT specifically, and not simply possess knowledge in their particular field (i.e., physical therapy, speech therapy, or computers) to be considered qualified. This area is not classified under assessment according to one of the experts.

Category 21 concerns the *Environment* and consists of two subcategories, *Environmental Assessment* and *Trials in Environment*. A comment made by a panelist was that these subcategories are "very, very" important to the assessment process. This was reflected in the percentage of favorable ratings ("very important" or "important") that were calculated from the survey. The scores were 97% for *Environmental Assessment* and for *Trials in Environment* on the first round, with a strong consensus indicated by the majority of experts rating this category as "very important." One of the panelists stated that this area is vital to ensure long-term use of a device. Two respondents cited the lack of the ability to procure a team of specialists to assess the AT needs of the individual in many instances. One of the panelists conceded that realistically this area is practically impossible to fulfill. Another of the panelists stated that often trials do not last long enough to prove the worth of the device to the individual. Another respondent points to the fact that we cannot fully assess the person for the proper device if we do not determine “where, how, and when” they will use a device. An expert expressed the viewpoint that if an individual is in a specific environment, he/she simply needs to be assessed in that environment (e.g., educational environment). A panelist working in Mexico reported that she must recognize the environment in which the person lives, because in a developing country like hers, people may not have electricity or money for something such as a battery for a device.

Category 22 was classified as *Trials/ Devices* with eight subcategories including *General Computer Competencies, Input Devices, Output Devices, Device Flexibility, Compatibility, Technical Support, Family or Support Personnel,* and *Affordability*. All of these subcategories were deemed as necessary to the assessment, except *General Computer Competencies* and *Affordability*. Both *General Computer Competencies* and *Affordability* were believed to be unnecessary to the assessment process with only 70% of the panelists rating these as “very important” or “important” in the first round. *Input Devices* as well as *Output Devices* were held by the panel of experts as an extremely important component of the assessment with scores of 97% and 97% respectively for the percentage of “very important” or “important” responses on the first survey. However, *Input Devices* and *Output Devices* were eliminated from use in the second survey because it was determined through the comments of the respondents, and by the researcher that one or both of these are the end result of any assessment, and therefore are not truly part of the survey assessment. Both input and output devices will be tested, but invariably anyone performing an assessment for computer access will include one or both of these devices in trials. *Device Flexibility, Technical Support, and Family or Support Personnel* were all rated as “very important” or “important” to the assessment by 97% of respondents revealing that these areas were thought to be essential with a strong consensus. *Compatibility* was also thought to be exceedingly necessary to the assessment of these individuals for computer access. *Compatibility* was rated as “very important” or “important” by 94% of respondents. Comments attributed to this last category were that it was difficult to rate the subcategories using these measures according to two of the respondents. One felt that all of the categories were important, and was unsure exactly what was being asked. Likewise, another also believed that all of the categories appeared to be “very important” to her. There was also an opinion given that these areas are not relevant to the assessment, but are features of the device and are the same “type of information.” Another suggested that it would be interesting to see the categories prioritized in the survey. One participant felt that each item in this category was necessary and is linked to the ability of the person if all device features are equal. A panelist emphasized that “quantifiable data” is needed to make the determinations in this category. Another respondent considered all of these subcategories as critical; thus, the reason we need a team is so that information is not missed in the assessment of any one of these areas, resulting in improper AT prescription. One of the panelists commented that the use of these devices may occur in environments where they are turned on for the individual (referring to *Computer Competencies*), but that all of the other areas are necessary to success in AT prescription. Price is a factor in the assessment—albeit a low priority—and should not take precedence over improved functionality by using the device according to another panelist. A statement by one of the experts was that alternative funding and collaboration are the areas that often are not instituted in the assessment. One of the panelists felt that an additional area needed to be added to the survey—*Follow-up*—because of the necessity to plan ahead to have the team revisit the user's needs and modify the intervention based on any changes. A respondent from Mexico stated that her choices are very limited because there is no rental option for trials, making it very difficult to choose the best device because of restricted availability.

Second Iteration

The first category in the second iteration was *Prior or Current Use of Assistive Technology* with the same subcategory as the initial iteration, *Prior Utilization.* This subcategory elicited a score of 92% on the second iteration for "very important" and "important" ratings by the respondents, indicating that this area is an essential element for assessment. There was a moderate consensus with 15 participants rating this area as "very important." Two of the experts felt that it was extremely critical to obtain a history in order to test alternate approaches, or to gain insight into prior exposure to technology. Another speculated that this area could be utilized to develop an understanding of the individual's "knowledge and skills" and augment these abilities. There was a remark by a panelist that this data may be used to determine how early technology was instituted for an individual and may assist in knowing how well a person may adapt to change, particularly if they were exposed to AT a young age. One of the panelists felt that this category may be useful in certain circumstances, but should not be used to establish "prerequisites" that will diminish the relevance of this data. She expounds on this idea stating that she could have answered differently, but chose "very important" because one needs to know what has worked and why. One of the respondents stated that it is a mistake to utilize information in this category on prior use or achievements to deny trials using particular devices, while another felt that this category is nonessential, although the familiarity with AT may help the individual being assessed.

Category 2 looked at *Medical Background* and consisted of *Health Exam* as the subcategory, identical to the initial iteration. This area garnered a score of 85% for inclusion based on essentially the same number of “very important” or “important” responses, suggesting a moderate consensus. Distinctions exist between what different members of the team need to know or require from the medical record according to one of the panelists. There may be significant changes in medical conditions over a period of time according to three of the respondents. One expert pointed out that the medical exam should not be a limiting factor, which may result in preconceived notions that a person is limited in their capabilities, without first performing a functional assessment. A panelist noted that she felt that this area is significant, but if the medical condition is fairly stable, this category is less of a factor. Another agreed commenting that if the condition is longstanding, the diagnosis may be all that you need. Another relevant aspect of this category is the effects of medication on the individual according to one of the experts. A panelist remarked that an individual’s medical condition has implications for implementing certain forms of AT for access.

Category 3 was *Family Background,* and contained only one subcategory, *Support Resources,* one less than the initial survey. This subcategory was rated as “very important” or “important” to the assessment process by 96% of the respondents, with a fairly strong consensus. Three of the respondents felt that this subcategory was closely related to abandonment. One of the experts made reference to the family, who promotes increased dependence if not convinced of the benefits of AT. Another respondent concluded that the “motivation and initiative” to operate a device can be spurred by the family. A panelist described a “support network” that will be required for the start-up phase, and continued use of the device, with another respondent expressing that the family or caregivers provide support on a daily basis.

Category 4 remained *Cultural Factors* with the same subcategory as the first round, *Cultural Values*. This element received “very important” or “important” rankings from 74% of the expert panelists, below the benchmark of 80% set by the researcher to determine inclusion in the assessment. This is another area that is closely linked to abandonment, and is a significant underlying factor when attempting to encourage use of a device according to three of the respondents, particularly if they are accountable for the AT device according to one respondent. A panelist surmised that goals for using a device are corollary to contemplation of many of the other elements such as culture, device features, and school environment to name a few. This area is associated closely with family background, and there must be acceptance on the part of others in order to have a favorable outcome according to another expert. Another offered the comment that you must listen to what the family says in order to ascertain if members of the family will be supportive, respecting their culture and values. One respondent did not feel that this area was very important unless the cultural values deny the use of AT.

Category 5 was *Educational Background,* comprised of only one subcategory, *Supportiveness of School Staff*, instead of three subcategories on the initial iteration. This element attained a score of 93% on the second survey, with a strong consensus evidenced by a significant number of “very important” responses for incorporating this area into the assessment. One of the responses to this category emphasized that it was

“Very, Very Important!!!” Two panelists reiterated a comment made about the family and caregiver (i.e., the school staff confer support on a daily basis). One of the experts commented that if the person being assessed is still in school, the absence of support will ensure failure of the AT intervention. Support for AT is mandatory in order to comply with federal legislation, and there should be no disparity between schools according to one of the panelists. Another panelist added that you must respect and enlist help from all involved, or success will be very difficult. A respondent felt that this category also includes educational history.

Category 6, *Goals for Use of Assistive Technology* retained the same two categories, *Assessment Team Goals* and *Individual/Family Goals*, with 100% and 92% ratings respectively for “very important” and “important” responses in the second round. Both of these categories remained elements that warrant inclusion in the assessment instrument with a strong consensus by the experts. One of the respondents commented that long term goals for utilization of a device are extremely consequential.   The goals of the individual and the AT team may be distinctly different according to one expert panelist. Another expert stated that all environments in which a device will be utilized must be evaluated in order to integrate the technology into daily activities. Whether or not the intervention is for school or Electronic Aids to Daily Living (EADL) will affect the goals that are set according to another respondent.

Category 7, *Communication* encompassed three subcategories, *Expressive Communication*, *Language Disorders*, and *Receptive Capabilities* all of which were subcategories in the first survey round. *Language Disorders* and *Receptive Capabilities* were found to be necessary elements in the assessment with scores of 88% and 85%

respectively with a moderate consensus, while *Expressive Communication* gained 78% of "very important" or "important" ratings. Two respondents felt that this area is crucial to establishing a foundation for training, with one also extending the importance of communication to routine use of the device. According to one expert, this category does not expressly exclude persons on the basis that they must understand what they read or have oral or written abilities to communicate, but should take into account the ability to convey his/her thoughts in some manner such as recognition of symbols or the ability to express himself/herself through pointing, eye gaze, etc. Another panelist claimed that this area is one that will have a significant effect on the way someone is perceived by others. Two experts working as speech pathologists expressed the need to utilize information in this category to determine device features, with one stating that during the assessment it is not requisite that a person has the capability to communicate. One of the experts felt that this area becomes even more crucial to those who are being evaluated for computer access and will use the device primarily for speech output. Another stated that the student's capabilities are the key to matching the student to the device in a particular environment. A respondent commented that this category is extremely difficult to test accurately, but suppositions may be made if a person is observed for a prolonged period.

Category 8 was *Cognition* and consisted of *Cognitive Function* and *Observations of Impairments,* the same subcategories that were on the first survey. Both of these areas were found to be essential to the assessment process with 89% of participants rating them as "very important" or "important" with a fairly strong consensus. These subcategories are closely associated with the functional abilities of the person being assessed according to one of the panelists. Another reiterated what was said for category 7, namely that this element is closely linked to training and utilization of a device.

Behavior was designated on the survey as category 9. The three subcategories, *Affective Characteristics*, *General Personality Traits*, and *Disordered Thought Processes* remained as the subcategories from the first round and were also found to be integral to the assessment in the second round with scores of 88%, 85%, and 96% respectively for the percentage of "very important" or "important" responses. A strong consensus was not evident, with more persons rating the subcategories as "important" rather than "very important." Similar to a comment registered for category 8, this category relates to functional ability and will influence the kind of device that will be prescribed according to one of the panelists. A respondent noted that this category is particularly important with regard to expensive forms of technology. It will also affect whether or not a device is abandoned according to one of the panelists. A panelist opined that this is an area that makes it troublesome to assess cognition if the individual is profoundly challenged. Another of the respondents simply felt that this category was worthy of consideration.

Category 10 was *Attention*, and *Attentiveness* was repeated as the subcategory from the initial iteration and remained meaningful to the assessment in the second iteration with a score of 96% for "very important" or "important" rankings. However, the consensus was somewhat low with only nine out of 27 respondents rating the subcategory as "very important." A comment was proffered stating, "Multi-tasking is a mainstay of AT!!!"

Intelligence was used in category 11, minus one subcategory, *Formal Measures.* The subcategory that was retained was *Observation of Performance.* This area reached a score of 85%, albeit with a moderate consensus on the second survey. One of the experts felt that caution should be exercised when trying to judge intelligence, which can be very "subjective."

Category 12 was depicted as *Memory*, and contained the same subcategories as the first survey, *Declarative and Procedural Memory* and *Semantic Memory. Declarative and Procedural Memory* remained material to the assessment with a score of 81% and a strong consensus. *Semantic Memory* gleaned "very important" or "important" ratings by only 70% of respondents. This area will dictate the "…format and use mode/layout of AT options" proclaimed one of the experts. Another expert declared that motor memory requires repeated training by the staff working with a person on certain tasks, and you must try novel ways to keep the staff interested, especially in repetitive-type tasks. Again, this was another area that affects training and utilization of a device. A respondent commented that there is a need to adapt or tailor the device in relation to memory deficits.

Social Adjustment was used in category 13, but was reduced to one subcategory, *Observational Analysis.* This area did not retain its significance to the assessment in the second round with only 67% of respondents ranking this as "very important" or "important." The sole comment offered was that this element shows how AT can be integrated into the daily tasks of the person according to one panelist, and one must be attentive to varying levels of performance in individuals.

Category 14, *Sensory/Perceptual* reintroduced the subcategories listed on the initial survey, *Sensory Input* and *Perceptual Input. Sensory Input* was slightly below the benchmark set at 80% with a score of 78%, while *Perceptual Input* obtained "very important" or "important" classifications by 85% of the respondents, with a moderate consensus. As in the category *Social Adjustment*, this area is also influenced by difficulties with daily activities according to one panelist, and AT may be used to "compensate" for these problems. A panelist asserted that this is an area critical to the assessment of the profound and multiple disabled.

Category 15 was *Vision*, retaining the subcategories *Visual Acuity* and *Visual Perception* from the first round. These subcategories remained material to the assessment in the opinion of the experts in the second round with scores of 81% and 93% respectively, and a strong consensus for inclusion. A comment was made that the visual ability of persons will affect the presentation or layout of the features used in a device. Visual problems severely restrict potential devices or the performance of tasks, and compel the team to make completely different choices than would be made for a similarly functioning person with vision. One must be aware that there may be no accurate means to enable testing of this area according to one respondent. Another of the panelists stated that, "FUNCTIONAL vision is very important—not just acuity." A panelist revealed that both "personal" and "professional" measures will impact the use of AT.

Auditory factors were used for category 16, and repeated the same subcategories as in round one, *Auditory Exam* and *Auditory Processing*. *Auditory Exam* did not meet the criteria for inclusion in the second round with a score of 74%, while *Auditory Processing* attained a score of 85% for "very important" or "important" responses, indicative of a continued consensus, albeit moderate, for inclusion in the assessment instrument. This relates to sound output from AT devices and will affect what device can be prescribed according to one of the panelists. Another respondent compares this category to vision, and the likelihood that it will be problematical when attempting to assess this category. Yet another comment was repeated by a panelist responding that "personal" and "professional" standards will influence the use of AT.

Motor Control was used for category 17 with all seven subcategories retained from round one, all of which were again deemed as necessary to the assessment for computer access in round two of the survey. The percentage of responses marked as "very important" or "important" in these subcategories were as follows: *Muscle Strength* (89%), *Muscle Endurance* (89%), *Coordination or Movement Quality* (96%), *Muscle Tone* (89%), *Functional Mobility* (85%), *Fine Motor Coordination* (96%), and *Motor Responses or Initiation* (96%). Additionally, there was a strong consensus for inclusion of all these categories. A comment by an expert was that this category should be contingent upon the assessment of functional tasks in order to establish adaptability features to be used for access. Potential locations for placement of an AT device that is operable by the individual being assessed may be excluded due to other factors such as difficulty mounting, etc., according to another panelist. A panelist reiterated that "personal" and "professional" benchmarks will affect the use of AT.

Range of Movement was used in category 18, with the subcategory *Range of Motion* used in the initial survey. There was also agreement on the second survey for incorporating this element into the assessment instrument, with a score of 85% rating this area as "very important" or "important" with a moderate degree of consensus. An expert restated that "personal" and "professional" criteria will determine to what extent AT is utilized.

Category 19 looked at *Posture* and continued with the same subcategories as in the first iteration, *Scoliosis or Kyphosis*, *Postural Stability*, and *Postural Support*.

Scoliosis or Kyphosis was ranked by 78% of the respondents as “very important” or “important” to the assessment process, whereas *Postural Stability* and *Postural Support* achieved scores of 93% and 85% respectively through a moderate consensus. One of the respondents speculated that this category is a prerequisite for any assessment or, according to another panelist, fundamental to any AT assessment.

Team Approach was used for category 20 and retained the two subcategories used in the first round, *Collaboration* and *Qualified Team Members.* These areas were found to be essential to the assessment with a very strong consensus between panelists for inclusion of both elements. *Collaboration* and *Qualified Team Members* received scores of 96% and 100% respectively, with a vast majority of responses judged as “very important” for both subcategories. A panelist remarked that the assessment originates with the formation of a team, while another stated that more input from team members is the basis for a quality assessment. The team process should at least be “consultative” if individuals are not able to meet face to face according to one of the respondents. A panelist noted that one must always, without exception, employ certified individuals on the assessment team. Another of the experts disagreed, stating that possession of a certificate in AT does not make an individual “qualified.” An expert commented that one must exhibit deference to the opinions of others and listen to their input regarding the person being assessed.

Category 21 was delineated as *Environment*, utilizing the same subcategories as round one, *Environmental Assessment* and *Trials in Environment.* Both subcategories received scores of 100% with a strong consensus by the panelists. One of the panelists postulated that it is not possible to observe if a device enhances function without testing the device in the individual's natural environment. Another of the experts regarded the SETT framework as a useful model to address this area. There needs to be an adequate assessment of the various environments for express purposes, or for `broad nonspecific uses of a device according to one expert.

Category 22 *Trials/Devices,* contained four out of six subcategories that were included in the first iteration, and a subcategory was added at the urging of one respondent. The subcategories were *Device Flexibility, Compatibility, Technical Support, Family or Support Personnel,* and the sub-category *Follow-up* that was added from the first round. All of these categories were considered to be necessary to the assessment process for computer adaptability using AT gaining a strong consensus. The subcategories attained the following percentages for rankings of "very important" or "important" to the assessment process: *Device Flexibility* (96%), *Compatibility* (96%), *Technical Support* (96%), *Family or Support Personnel* (100%), and *Follow-up* (100%). All of these categories achieved a strong consensus for inclusion by the panelists. All of the team members should be involved or have input during trial use, without favoritism toward the opinions of a particular group according to one respondent. An expert regards follow-up as essential, especially in children, and failing to account for changes in the individual due to lack of consistent follow-up is problematic.

One of the expert panelists commented in an addendum at the end of the survey referring to all of the categories that, although she rated a significant majority of the elements as very important, all of these are not needed in every assessment except in a person with severe and multiple disabilities. I would also like to mention the fact that one of the participants began the second survey and quit approximately midway through because he recognized that he was selecting “very important” for all categories. Therefore, his survey responses were tallied as “very important” for the entire survey. The respondent espoused the view that it would be “difficult to incompetent” for anyone to designate these elements as something other than “very important” to a global assessment. He acknowledges that the assessment areas may not be used in some settings that are examining specific tasks. Notwithstanding, the computer access assessment should be wide-ranging in its scope when initiated in order to be effectual, and then it will become more focused as the team attains a convergence on certain elements. The ability to cull the relevant facts from a substantial database of information will enable a holistic approach to the assessment process.

Qualitative Analysis

There are numerous inferences that can be drawn from the data collected in the literature review and the survey of the panel of experts. The literature speaks to a multitude of deficiencies that have been observed in the assessment process for computer access. In many instances, these problems do not allow for a comprehensive assessment of the individual. There are a myriad of areas that should be given scrutiny during the assessment process, necessitating a team approach to adequately address all of the person’s needs. The major intrinsic categories that should be considered based on the expert opinions of the respondents to the Delphi study are listed in Table 4. The extrinsic factors that should be incorporated in the assessment based on the survey results from the Delphi study are also listed in Table 4. This is particularly true in persons with multiple disabilities such as those with brain injury.

There are inherent obstacles to prescribing the proper AT device to assist persons

Table 4: Essential Elements for Assessment for Computer Access

Intrinsic Elements	Extrinsic Elements
• Health Exam • Language Disorders • Receptive Capabilities • Cognitive Function • Observations of Impairments (Cognition) • Affective Characteristics • General Personality Traits • Disordered Thought Processes • Attentiveness • Observation of Performance (Intellectual) • Declarative and Procedural Memory • Perceptual Input • Visual Acuity • Visual Perception • Auditory Processing • Muscle Strength • Muscle Endurance • Coordination or Movement Quality • Muscle Tone • Functional Mobility • Fine Motor Coordination • Motor Responses or Initiation • Range of Motion • Postural Stability • Postural Support	• Prior Utilization • Support Resources (Family) • Supportiveness of School Staff • Assessment Team Goals • Individual/Family Goals • Collaboration • Qualified Team Members • Environmental Assessment • Trials in Environment • Device Flexibility, • Compatibility, • Technical Support • Family or Support Personnel • Follow-up.

with computer access due to the complexity of their conditions. There is a plethora of technological devices to assist individuals with a multitude of tasks. However, the assessment process can be problematic when evaluating persons having one deficit, much less those with numerous impediments. There needs to be a set of criteria to judge assessment instruments, especially in persons with multiple and severe handicaps secondary to neurological conditions.

The field of neuroscience has demonstrated the intrinsic complexity of the nervous system through recent advances in imaging and other methods of research. In my review of the literature regarding central nervous system function I was able to ascertain many new findings in the field related to brain injury that would impact the assessment of disabled individuals for computer access. The research demonstrates the interdependence among many of the various functions of the CNS in order for a person the carry out tasks such as those associated with computer access, and the ability to utilize an AT device to accommodate for a disability. One of the foremost recurring concepts in the contemporary literature has to do with the fact that although there are various functions attributed to different parts of the brain, numerous areas of the brain are utilized simultaneously in order to complete a variety of tasks. This is referred to as *distributed* or *parallel processing*. This allows the individual a great deal of flexibility when attempting to complete a task, yet it also reveals the abstruse nature of brain injury that contributes to the complexity of the assessment process. This demands a comprehensive exam of a person to determine the impairments that are present. By virtue of the elaborate interactions between input and output signals to and from the CNS, and the integration of neuronal impulses in the CNS, we are able to regulate cognitive, sensory, and motor activities in order to carry out daily tasks. This interplay between nervous system structures may be interrupted through damage to areas of the brain causing dysfunction. Damage to the brain can occur at the primary level controlling basic functions or higher levels that interpret nervous system impulses or perform higher level processing tasks.

With regards to computer access, motor control is notably the most critical area that should be evaluated. Motor control has been studied extensively and has been found to involve a complex set of systems in order to produce goal-directed movements. Motor control occurs at all levels in the central nervous system: in the spinal cord, brainstem, and cortical regions. The cerebral cortex directs the most complex voluntary movements. Movement involves sensory feedback, awareness, perceptual factors, and cognition. All of these areas need to be assessed when looking at the deficits present in an individual. Movement and cognition are extensively intertwined and there is conscious intent for many of the volitional movements that we perform such as planning movements to access a computer. In the review of the literature a number of contemporary theories that have been developed for motor function were detailed, supporting the complex and multidimensional nature of motor control. The brain is a plastic, dynamic structure incorporating feedforward and feedback mechanisms to respond to stimuli using such things as vision and imagery to plan and execute movements. Areas of the brain overlap (i.e., distributed processing) in function and there is redundancy, allowing for planning of complex movements. Movements such as reach and grasp in the upper extremity have been studied extensively, illustrating the elaborate neurophysiological machinations that underlie these movements, including planning for conscious intent to perform fine motor tasks.

Sensory feedback is essential to executing a motor activity such as attempting to utilize a computer for a particular task. There is continual integration of sensory information influencing motor output to control movement direction or force in order to achieve voluntary and involuntary motor output to complete a task. Coordination of movements requires input from several different senses including auditory, visual, and somatosensory. If someone has sensory deficits they are unable to integrate sensory input in order to refine their movements. Persons need to assimilate and interpret sensory cues, both external and internal, in order to act in different contexts. This may include visuospatial information to perceive their orientation in space which is external. Another example is the ability to receive feedback on body position to sustain an erect posture or move the extremities, which is internal. In my estimation, this attests to the fact that sensory input (beyond simply visual or auditory input) is requisite for access and interaction with the computer interface, and should be an integral component of the assessment for AT; in spite of the fact that it did not meet the criteria on the Delphi study.

Cognition is another facet vital to planning voluntary motor movements to link to and operate a computer for school, work, or leisure. Cognition is associated with other sensory and perceptual functions, and also depends on memory to a considerable extent. The literature reveals that the mind and the body are interconnected with the mind making decisions regarding bodily functions such as how to plan and implement a task. Research studies have divulged information supporting the theory that the mind generates levels of consciousness progressing from a rudimentary sensory stimulus to planning of actions, ultimately spawning higher reasoning or metacognitive capabilities. Certain stimuli are recognized by the brain as significant in lieu of others expressed as conscious awareness, and are not simply lost. There needs to be some mode by which a person can structure their thoughts, remember their actions, and rationalize their perceptions in order to plan actions such as the use of a computer to perform a task. Conscious awareness helps us to judge the consequences of our actions and whether or not we should proceed or alter what we are doing at a certain instance in time, contingent upon what else is occurring at that moment.

There are a number of etiologies for brain injury. The AT assessment team should be cognizant of the causes and manifestations of different conditions. Brain injuries can happen before or during birth, or may be acquired later in life due to trauma or some other disorder. Timing of injury may impact the function of the individual. It is also important to be aware if the damage to the brain is focal or diffuse, which will determine impairments that may be encountered. For example, cerebral palsy is one condition that is often discerned in persons with brain injury causing diffuse damage, with a diversity of impairments affecting the ability to function in many different domains. As in other types of brain injuries, CP involves a complex interaction of motor, sensory, emotional, and cognitive impairments that restrict function. Moreover, the literature discloses how the direct consequences of a lesion such as involuntary muscle contractions in a condition such as CP can cause limited range of motion or contractures as a secondary problem. There are numerous other conditions such as strokes or metabolic imbalances that also must be assessed for their unique effects on the individual. The complex of impairments that characterize severe neurological conditions necessitates a thorough assessment by a team of competent professionals in conjunction with the individual and their family or caregivers to identify the salient factors that will impact the use of AT for computer adaptations.

It is apparent from research into brain function that one neurological insult can cause multiple impairments, making it problematic when assessing function. The four major categories of deficits can be broadly divided into behavioral, cognitive, communication, and sensory-motor deficits. Motor problems are evidenced in a variety of ways, extending beyond simply muscle weakness. In addition to, or in lieu of true weakness of the muscles, other problems may be detected such as coordination deficits, spastic muscles, or impaired muscle activation. Individuals may show weakness not only in the extremities and trunk, but may also display deficits in the head, neck, face, pharynx, larynx, and muscles of respiration. The individual will also exhibit flawed movements if they have poor attention or alertness. Abnormal patterns of movements (abnormal synergies) or involuntary movements are examples of two kinds of impairments that may be identified when evaluating motor function for computer access. Another consideration is that impairments may stem from multiple sources. The team may distinguish problems such as impaired muscle activation in which the individual is unable to maintain a stable posture that may be multifactorial (e.g., abnormal sensorimotor integration, muscle weakness, and muscle contractures).

In my review of the research on neurological function, the presence of sensory and perceptual problems was noted to cause significant disabilities in persons with brain injuries. These impairments, combined with motor, behavioral, and cognitive problems can make it very difficult for an individual to access a computer in any meaningful way. Absent or limited sensation may occur in a variety of patterns in any body region, and on one or both sides of the body. If the team is not aware of these deficiencies during the assessment process, they cannot make the accommodations necessary to enable the person to overcome these deficits. For example, if a person has hemineglect they may not attend to one side, and the switch or other input device may need to be positioned differently to enable them to operate the computer. Another example would be the inability to visually recognize colors requiring a different mode of presentation of material. Only through comprehensive screening and judicious trials with a number of devices can the team identify and accommodate for perceptual and sensory impairments.

The psychosocial aspects of brain injuries should be scrutinized during the evaluative process for computer access in persons with central nervous system impairments. Neuropsychological conditions have been categorized into mood, behavior, and cognitive disorders. Problems limiting the ability to use a computer to perform a task may be things such as attention, the ability to remember, or the ability to reason. This will require adaptations to the computer to allow a person to interface with the device and software to help them to attend to tasks or plan tasks in order to perform certain activities. There may also be concomitant behavioral problems or behaviors that need to be addressed. Devices that may make using the computer simpler or less frustrating may aid in minimizing disruptive behaviors. The cause and effect relationship between impairment and disability is difficult to establish in brain injury due to the multiplicity of interrelated elements. Oftentimes, it may not only be one disorder such as inattention, but several factors simultaneously such as memory or the ability to process information making it difficult to assess function for an AT device. The individual should be able to gain some mastery over tasks that he/she attempt to execute and acquire the capability to plan and organize a task to accomplish an objective. Persons with brain injuries have been shown to have a diminished capacity to complete even simple tasks, and usually have considerably more difficulty with complex or multi-step tasks. Memory deficits in conjunction with impairments in executive functioning or abstract thought can place significant constraints on problem solving ability. The psychosocial aspects of brain injury are integral to the assessment of individuals for adapted computer access utilizing a suitable AT device.

In my literature review the assessment process was found to be inferior in many respects, such as ill-defined procedures, absence of a team approach with qualified personnel, poor communication, minimal attention to the needs of the individual and his/her environment, and a lack of follow-up. Items in the literature that have been recognized as facilitatory to the assessment are the inclusion of individual or family goals, proper technological features, adequate service system, family support, cultural sensitivity, environmental determinates, and past medical or educational history. The team may begin by assessing a person's postural alignment, sensation, muscle tone and strength, range of motion, and other physical characteristics including the evaluation of fine motor skills, vision, hearing, tactile sensations, coordination, and mobility. The research emphasizes that the assessment should occur in a person's customary environment rather than a controlled setting.   Other measures have been identified in the research and should be adopted in a comprehensive assessment for computer access. These include: cognitive/linguistic awareness for comprehension, expressive and receptive communication, emotional responses, response to stimuli, attentiveness, personal/interpersonal relationships, awareness of the environment, learning, language, and memory. The supportiveness of other students, teachers, and family should also be ascertained. There are many assessment tools available, though one is not necessarily better than the other. Therapists are often the ones who prescribe AT, but may need outside assistance from specialists in other fields. The device must be accepted by the child or adult for use in his/her own environment, or no assessment will be successful.

Interpretation of the Findings

Researchers have developed several models that can be used to assess for computer access using AT. In essence most of these refer to the characteristics of the person, the tasks that he/she will be required to complete in his/her own environment, and what devices will be utilized. The intervention that will be used is contingent upon what impairments are detected when conducting a thorough exam of the person. Follow-up with training for the individual and those working with the individual is critical for success. Unfortunately, there is a consensus in the literature that assessment instruments are largely inadequate for persons with severe neurological problems and multiple disabilities. There have been attempts to enhance the quality of assessments for persons with brain injury utilizing different methods of neuropsychological testing incorporating physical, psychological, and social factors through standardized instruments and observation to detect impairments. However, these may not necessarily be reliable assessments. Rigorous assessment of the needs of this population has been largely ignored. To assess persons with multiple and severe disabilities, allowances need to be made for motor, sensory, perceptual and cognitive deficits.

I have located one study (Lahm, Bausch, Hasselbring, & Blackhurst, 2001) in my literature review listing elements for an AT assessment for computer access, although it did not emphasize persons with severe neurological deficits. The Delphi procedure was also utilized, with agreement on 63 elements that should be included in an assessment. The authors did stress that everyone is different, and that it is important to look at each person's individual characteristics. However, there are shared characteristics among individuals enabling the development of specific categories. The inference that can be made from the study was that after incorporating the various elements into a comprehensive assessment, the result should be a device that is simple to use and effective. No device that is arduous for the person trying to operate the computer to use, no matter how good the assessment, will be of benefit. The person's abilities should be commensurate with the skills it takes to operate the computer; otherwise, the technology will be useless. Sensory, motor, and cognitive capabilities must be tantamount to the input and output features of the AT device to enable independent use of the device with a minimum of outside help. The individuals with the most severe disabilities usually require the most customized devices. All of these principles need to be resolved during the assessment and trials before prescribing the device.

CHAPTER V

CONCLUSION

General Conclusions

Berger, Leven, Pirente, Bouillon, and Neugebauer, (1998) measured the quality of life, specifically for persons with TBI. Berger performed a literature review of studies regarding brain injury and quality of life issues using a variety of instruments, mostly for persons with severe brain injury in order to appraise deficits in physical, psychological, cognitive and social spheres. Individuals initially suffer from the physical problems of paralysis and the inability to walk and coordinate movements impacting their quality of life. Yet, cognitive factors (decreased attention, memory, learning, concentration, and orientation) appear to have the most long-ranging affect on the person's daily existence. Affective disorders such as mood, emotions and behavior have also been found to have a significant influence on function, while depression and anxiety can also cause problems, most notably with social adjustment. The authors stress that there is a need for valid instruments to analyze these disorders. Hopefully, with improved assessment measures, progress can be made in interventions such as assistive technology that can enhance the function of these individuals and improve their quality of life.

The impact of severe neurological conditions can be ameliorated by the new technology being developed to enable disabled individuals to improve their lives. However, neurological disorders can be very perplexing with respect to assessing the abilities or disabilities of the individual. This has been substantiated in the contemporary literature with advances in neuroscience that reveal the complex nature of brain function.

Although there has been mapping of the brain revealing areas that perform specified tasks, the concept of *distributed processing* where the numerous areas of the brain contribute to the execution of many different tasks, instead of distinct functions being performed by discrete areas of the cortex has been promulgated. This has implications for brain injury and interventions to improve the function of these individuals. Oftentimes, an individual may have sustained some type of injury or pathology that causes not only a particular deficit in function, but numerous affiliated impairments. These associated problems contribute to the impairments generated by the condition. This has implications for the area of AT for computer access and the necessity to perform a comprehensive assessment in order to encompass all possible impairments in need of remediation. If an area is missed, this may invalidate the assessment and result in failure of the device. This also reveals the importance of a team approach in which trained professionals can use his/her expertise to assess the diverse areas that need to be examined. The desired outcome is that the AT device(s) that are being prescribed are commensurate with the abilities of the individual, and are not cumbersome to use. The operation of a device should not be so elaborate that the person assigned a particular type of AT requires more than a bare minimum of effort and training to utilize the device effectively.

Discussion of the Findings

The first area to gain a consensus for inclusion in an assessment for computer access was *Prior Utilization*. This was the only element included under category 1, *Prior or Current Use of Assistive Technology*. This element was considered to be critical to the assessment process for a number of reasons by the respondents. This area was vital because the past history and experiences utilizing AT for computer access can determine what may work in the present. In addition, prior use will enable the assessment team to gain insight into the skills that the individual may have obtained by using the technology. However, one should be cautious when interpreting the data and not place too much emphasis on what has worked or not worked in the past. This should not narrow the focus of the examiner or bias the assessment against a particular form of AT. There are many more considerations such as how long it has been since the individual used the device and the extent to which his/her condition has changed since they were prescribed the device. There is a significant benefit in developing a record of what an individual has had success or failure with, although there may be extenuating circumstances such as the quality of the prior assessment and follow-up, that may have impacted the individual either positively or negatively.

With regard to category 2, *Medical Background*, the lone subcategory, *Health Exam*, was considered as important to the assessment process, although it did not gain the level of consensus that *Prior Utilization* did. There were a number of reasons extended in support of why this area should be incorporated into an AT assessment. Using this data to ascertain the condition of the individual, and what may be expected of him/her with regards to how they may function with the impairments that they have is crucial. However, there is still individual variability, and one cannot rely exclusively on medical records to assess needs. Placing restrictions on the individual because of their medical diagnosis or diagnoses should not be an accepted practice. This also reveals the importance of understanding the problems that may be encountered in various conditions, in order to more accurately interpret the medical record and explore options for accommodation. The members of the assessment team will have differing levels of knowledge and experience with regard to the physiological basis underlying certain conditions. Evaluators may also rely too much on this data, and classify someone as lower or higher functioning than his/her true abilities actually allow. Medical records are good for determining whether a disease state is stable or progressive, and how treatment of their condition by the medical community has impacted the person related to AT interventions. The assessment team should be prudent when obtaining medical background from individuals associated with the person being assessed because of the possibility of inaccuracies. One of the participants felt that medical history is only important when it pertains to the condition. I believe that it is erroneous not to examine the medical records if available, since anyone with a disability is certain to be under a physicians care. One would be remiss if they did not attempt to gain insight into the person's disability. However, if the medical condition is severe, the bias on the part of the assessor denying that the person has the potential to utilize certain types of AT devices may be magnified. I would concur with the statement of one of the experts that a functional assessment will have more relevance to what device is prescribed, beyond what the medical record describes.

Category 3 encompassed *Family Background* and specified two subcategories, *Economic Resources* and *Support Resources*. *Economic Resources* should not affect the device that is prescribed for the patient, and was not included in the second round of the survey. However, family support resources garnered a strong consensus. In essence, if there is no effort or commitment for follow-up by the family or caregivers on a continual basis, more than likely there will be no sustained use of the device. There is the recurring problem of abandonment of the device when there is no motivation or incentive to use a device if those around do not accept or advocate its use. Therefore, it is critical to assess what the family or caregivers will endorse, even though it may be less than optimal in the opinion of the AT assessment team. As one of the expert panelists so aptly articulated, the family will only foster "increased dependence" in an individual if he/she rejects the use of devices for access. The success of the device may hinge on this element, even though all of the other areas have been addressed. Furthermore, the recent literature strongly advocates inclusion of the family or caregiver in the assessment process from the outset.

Cultural Factors were represented in category 4, with C*ultural Values* as the subcategory. *Cultural Values* was an area that did not obtain a high measure of consensus as a crucial element to the assessment process according to the respondents in the Delphi study. In fact, it failed to reach the benchmark of 80% of respondents rating this area as "very important" or "important" to the assessment process, albeit by a relatively slim margin (75% in the first iteration, and 74% on the second). Culture appears to have become a concern in the recent literature related to AT, and there was not a strong consensus for eliminating this area. There were individual respondents who argued for retaining this element with statements to the effect that this is one of the most omitted areas of the assessment process. Due to the score on the initial iteration and the comments in support of *Cultural Values*, it was preserved for the second round of the survey. Notwithstanding, *Cultural Values* may be a redundant category, and could be subsumed under support resources. Culture is part of the family dynamics and may certainly be regarded as a characteristic involved in the family support system, therefore impacting the AT devices that can be chosen. A number of experts did not acknowledge that this category warranted consideration as a distinct element in the assessment. However, *Culture* should—at a minimum—be incorporated into another area such as *Family Background*, justifying some deliberation of this element.

Category 5 addressed *Educational Background* containing three subcategories: *Formal Education, Academic Testing*, and *Supportiveness of School Staff.* Both *Formal Education* and *Academic Testing* were not judged as imperative to AT assessment according to the majority of respondents in the first round, and were therefore eliminated in the second round. This was buttressed by my review of the literature that there are really few valid methods for testing persons with disabilities, especially those with severe disabilities for intellectual or academic performance. It is difficult to discern what a person is truly capable of intellectually in instances where that individual has problems in areas such as perception or communication, and there is no means to access what he/she is thinking. Some of the respondents did feel that educational history was important. However, at least for those working in the school system, there may be more awareness of the problematic nature of testing, and the poor reliability and validity of current methods. With improvements in assessments for IQ and academic performance for those with disabilities, these subcategories may become more relevant, not only for children in the schools, but others who have matriculated through the school system. Currently, these measures are likely of little use in either children or adults. *Supportiveness of School Staff* gained a strong consensus for inclusion on the first and second iterations. This element is indispensable to the success or failure of AT for computer access in the school environment, and one should ascertain what measures should be taken to ensure compliance by all school personal. If there is no prior knowledge of the school environment and documentation regarding the willingness of the staff to support the use of a device, then efforts at improving the education of the child with what you may think is the best device is futile. Although the provision of AT services and devices is compulsory under federal law, this is an area where compliance is poor. This is likely due to a number of factors such as the lack of training, staffing, resources, or awareness of the benefits of AT.

With respect to category 6, *Goals for Use of Assistive Technology,* there was a strong consensus by the participants for inclusion of both subcategories, *Assessment Team Goals* and *Individual/Family Goals*. There is an increasing impetus for accountability in the field of AT, necessitating some measure of functional gain(s) when using the device. This underscores the need for establishing goals that can be used to predict some measure of improvement that will be realized by utilizing the device in various contexts. The expert panel stressed that goals should be realistic and that irrelevant or inappropriate goals will set the person up for failure. Moreover, it is also imperative that there be some concordance reached between the AT team and the individual/family receiving the device for determining mutual goals, since oftentimes there may be a marked contrast between the two. If the goals do not meet the needs and expectations of the user or AT team, there is little inducement to utilize the device. The environments in which a device will be used will also significantly influence the type of goals that are established. This is an example of the interdependence between the various assessment elements, and when considering a specific area, one must also look at data pertaining to other aspects of the assessment process.

Category 7 examined C*ommunication* consisting of three subcategories. The subcategories included *Expressive Communication*, *Language Disorders*, and *Receptive Capabilities*. These subcategories were felt to be necessary to the assessment, except for *Expressive Communication* at 78% for "very important" and "important" responses. One of the survey respondents felt that this area should be incorporated into the assessment only when communication is the goal. Nevertheless, there are many tasks that require communication between the individual or comprehension of what is communicated to them, making this an area that should be looked at for computer access in general. This concept was sustained by the responses of some of the other experts, noting that receptive communication is extremely important and the ability to discern cause and effect is critical for even the most simple of tasks. If the individual has communication deficits, there should be some type of intervention that relates function to improved communication. Impairments in this area can severely compromise the ability of the person to follow directions and respond to training in order to use the device. In contrast, the lack of reading comprehension or oral or written communication should not—according to some of the other panelists—restrict the assessment for the use of AT. If the person is able to utilize other modes for communication such as gestures or pointing to symbols, oral or written communication may not be a consideration. The review of literature supports the pervasiveness of communication problems in individuals with brain injury and their deleterious effect on the ability of the person to function.

Category 8 pertains to *Cognition*, and the subcategories of *Cognitive Function* and *Observations of Impairments* were rated as two of the more decisive elements that should be incorporated into an AT assessment. The abilities of the person relating to cognitive function are going to determine the complexity of the intervention being used and the expectations of what functions or tasks will be facilitated by using the device. Therefore, it is necessary to look at this area carefully. One of the panelists commented that a person may function at a higher cognitive level then may be apparent without a thorough exam. Other factors may influence this area (e.g., the individual may simply be slow at processing information, even though they comprehend what is being asked of them). If the evaluator is not cognizant of this difficulty and does not wait for a response or assist in eliciting a response, the true cognitive abilities of the person may not be realized. The literature reveals that this may be a difficult area to assess due to other impairments such as communication that are not accommodated for in the assessment. Scrupulous assessment of this area will impact what features are incorporated into the device. Cognition is closely linked to the potential to execute tasks and the awareness of ones capabilities to perform these tasks correctly.

Category 9 was labeled as *Behavior* with three subcategories designated as *Affective Characteristics, General Personality Traits,* and *Disordered Thought Processes*. All of these areas were thought to be important to the assessment process. One of the survey respondents noted that if there are problem behaviors this will deter her from prescribing certain devices. Underlying emotional issues should be addressed, and may even be ameliorated by AT according to another panelist. I believe that behavior impacts a person's abilities in a number of other areas. If the person is frustrated, feels inferior, or other issues are present they may "act out." There are also issues of self-abuse with some of the more involved clients. These will impact other facets of the assessment such as attention and social adjustment that need to be addressed. If the subject is severely impaired this is an extremely difficult area to evaluate. The literature describes the prevalence of problematic behaviors for individuals with neurological conditions. There are numerous causes and an infinite variety of manifestations of altered mood or behavior, making it extremely difficult to judge ways to address how these problems will impact the use of AT.

Attention was considered in category 10, with only one subcategory, *Attentiveness*. This subcategory was seen as important to the assessment, although the consensus was not as great for this area as some of the others. Consciousness or awareness, and the modes we use to perceive and interpret the outside world are a subject of much debate. There are many determinants of attention that may be impaired for a number of reasons. There were many comments in support of this area offered by the respondents. This area was felt to be crucial to the tasks that the individual will be required to execute using the technology, and will impact the complexity of the device prescribed to the individual. Attention is crucial to instruction in how to use a device and what steps are involved in executing more sophisticated tasks. Moreover, there is a connection between attention and many other areas that are involved in the AT assessment such as memory. For example, a person cannot perform a complex motor task without the ability to plan and execute a volitional movement repeatedly (i.e., using an input device to access and perform tasks on the computer by remembering a particular set of instructions).

Category 11, *Intelligence*, was comprised of two subcategories *Formal Measures of Intelligence* and *Observation of Performance. Formal Measures of Intelligence* was not identified as an area that should be included in the assessment for computer access in round one of the survey. One of the comments made supporting exclusion of this element was that IQ is not a measure that is a reliable indicator of how a person will perform. IQ measures have been questioned appertaining to their validity for indicating intelligence, particularly in those persons who fall outside of the norm. The executive functions of the cortex are involved in the most complex tasks. They are distributed throughout the brain and may be impaired in a number of conditions, or there may appear to be a dysfunction due to deficits in other areas such as perceptual abilities. *Observation of Performance*, which consists of how a person performs or is able to reason in particular tasks, whether simple or complex, and his/her area(s) of interest, may be a better indicator of what they are capable of intellectually. This subcategory was deemed important to the assessment process by the respondents. One of the panelists stated that evaluating function in a certain domain may be the best way to determine intellectual abilities. I believe this information can be supplemented, at least in the school setting by observations from the teachers, and even the parents in certain circumstances. However, this still will not be a precise determination of intellectual capabilities. One must look at multiple areas of intelligence (what an individual does best). However, this method may be nonobjective or prejudicial in terms of the competencies assigned to an individual.

Category 12 was termed *Memory*, and consisted of two subcategories, *Declarative and Procedural Memory* and *Semantic Memory*. *Declarative and Procedural* M*emory* was judged as necessary to the assessment, but the respondents did not consider *Semantic Memory* as critical to the assessment, and it was not included in the second round. There were a variety of reasons given by respondents to support their opinions. Prior memories are important in order to build upon a task and procedural memory is necessary to operate an AT device. Memory may also determine the complexity and features of the device because of the need to recall a series of tasks to control a device. Additionally, memory is requisite for new learning to occur, and if one has an impaired ability to make or store memories, then the device that is selected should not demand that a person recall multiple steps for operation. Memory involves the retention of information related to motor activities, learning, or the ability to reason, and will limit the use of technology requiring special adaptations. To enable a device to be utilized effectively and allow the individual to function using an AT device, the means by which a person accesses the device may need to be simplified. This may be accomplished with adaptations that facilitate use, such as visual (symbols) or auditory cues that streamline the process for using the technology.

Social Adjustment was presented next in the survey as category 13. It was comprised of two subcategories, *Observational Analysis* and *Basic Social Skills*. *Basic Social Skills* was not deemed to be important to the assessment instrument, although *Observational Analysis* was seen as necessary, yet only moderately so. *Observational Analysis* encompasses areas such as observing the person for awareness levels, interactions with others including insight into how his/her actions affect others. The experts believed that this is an area that is important depending on the context in which the person will be utilizing the device, and how he/she reacts or interacts socially in a particular environment. There are devices used for computer access that will be used to enhance communication, in which the capability of the individual to associate with others will be a factor in determining the level of complexity and the features to include in the device. There is ample evidence of how the ability to socialize is indicative of many of the problems inherent in persons with neurological conditions affecting communication, attention, cognition, or sensory/perceptual abilities. In my opinion developing measures in which observations of the individual's function in particular social contexts, and how these observations will affect the utilization of an AT device should be constructed. The importance of *Observational Analysis* hearkens back to the recurring concept in many of the assessment categories of both practical and functional measures to determine the most effective intervention. Certain AT devices will not be effective in individuals who have difficulty connecting with others if the expectations are that the AT device will allow them to do so. They may be able to respond to others at a fairly rudimentary level (e.g., using symbols, eyegaze, etc.).

Category 14 referred to *Sensory/ Perceptual* measures involving two subcategories, *Perceptual Input* and *Sensory Input*. Both of these subcategories were found to be very necessary to the assessment for computer access on the initial iteration. Only *Perceptual Input* was defined as useful in the second iteration. The respondents linked this category with communication and felt that the mode of communication would be determined by this area. Furthermore, a participant who works with the blind stated that this area would be the first to be assessed. Perceptual input is required for any interaction with the environment. It is necessary to acquire a response that is appropriate to the stimulus given to the individual. If a person does not have the ability to recognize what is displayed on an output device such as a monitor due to impaired visuospatial input, adaptations such as speech output may be necessary. Inaccurate processing of stimuli can significantly impede performance on functional tasks and is very prevalent in disabled individuals with severe and multiple impairments. For example, if there is impaired touch or proprioception, an individual may not be able to control the limb in order to operate an input device. This will profoundly affect the ability to perform tasks required for daily function when sensory input cannot be processed. Impaired sensation will influence areas dependent upon sensation such as motor abilities needed to volitionally perform a task such as accessing a conventional computer keyboard. Abnormal sensory input must be accommodated in order to generate a more appropriate response. Thus, even though this element only approached the 80% cutoff for ratings of "very important" or "important" on the second iteration, it was seen as necessary to the assessment on the first iteration. Impaired sensory input can profoundly impact how a person functions both physically and mentally, and is an integral part of the assessment. Impaired perception and sensation may severely limit the responsiveness of an individual to stimuli, the ability to initiate tasks, or the awareness of their surroundings.

Category 15 concerned V*ision*, and was divided into two subcategories, *Visual Acuity* and *Visual Perception*. Both of these areas were felt to be important to the assessment of the individual for computer access, with a fairly good consensus between the survey respondents. *Visual Acuity* relates to an eye exam for the ability to see up close or far that is performed by a professional. *Visual Perception* pertains to how we organize visual information and deals with things such as tracking and gaze and the ability to recognize objects. Once again this area has to do with input and output devices and what features will be used to accommodate for a disability. One of the experts commented that impaired vision was often the reason that someone is referred for an assessment. The need to consider visual deficits is analogous to category 14, since this is also an element that provides sensory input to the individual. Visual deficiencies may affect activities such as eye-hand coordination when assessing motor function, and one needs to consider how vision impacts functional activities, beyond merely testing how well a person can see an object. If an individual has the ability to see an object, but cannot process this information to construct what an object is, then his/her vision is impaired. Accommodations for impairments would encompass changes such as the placement of the monitor when there is a visual field defect, or altering the display on the monitor such as text and background colors to enhance contrast. Visual deficits can have a substantial affect on the type of AT devices prescribed for an individual.

Category 16 dealt with A*uditory* function, and consisted of two subcategories, *Auditory Exam* and *Auditory Processing*. *Auditory Exam* was not felt to be essential to the assessment of individuals for computer access, albeit by a very slight margin. However, *Auditory Processing* was deemed essential, and there was a moderate consensus for this area for inclusion in the assessment. The experts in the Delphi study commented that this area is similar to vision, and is often a reason for referral for AT services. I would also conjecture that this may be an area that is easily overlooked or misidentified as some other impairment. For example, if a person is not processing sounds normally, this may be mistaken for inattention or limited intellect. If there are difficulties with auditory processing, more visual enhancements may be needed. Auditory exams are very important, especially in younger children who may not have been identified as hearing impaired. Any decrease in the ability to discriminate sound that is not due to an auditory processing disorder will substantially influence the ability to effectively utilize technology. This is a major sensory deficit, and although the experts did not rate this as an essential element—although it did approach significance—it is difficult to conceive of a case where this element can be excluded. Display or output options such as speech to text or possibly simpler adaptations such as symbols for lower functioning individuals would be areas to consider. Furthermore, there may be other sensory deficits in persons with multiple impairments that are exacerbated by the inability to hear.

Category 17 was designated as *Motor Control*. There were seven subcategories in this category including: *Muscle Strength, Muscle Endurance, Coordination or Movement Quality, Muscle Tone, Functional Mobility, Fine Motor Coordination,* and *Motor Responses or Initiation.* All of these were believed to be essential elements to the AT assessment. There was a strong consensus for most of these elements, with several comments regarding the importance of this area. There was a respondent who felt that this area requires an extended assessment and that this is extremely important to the selection of the proper device and features of the device as it relates to function. There is some justification as to why this area has the most subcategories. There must be some manner of purposeful, volitional movement present in order to access a computer to complete a task. If there is not a part of the body that can be used to elicit a consistent response without excessive hardship to the individual such as fatigue or lack of automaticity, then it will be virtually impossible to utilize the technology. Using modern day technology, there may be a body region besides the hand such as the eyes, knee, facial muscles, and numerous other options available for computer access, although these areas may be overlooked if there is not a thorough assessment. This gives credence to the notion that the motor assessment is crucial, and an accurate assessment of this area is dependent upon many of the other elements that have been included in the survey. Functional measures are the most likely to identify the individual's motor abilities, and these measures are being developed according to the literature on new developments in the movement sciences. Motor control stems from reactions that must take place in a variety of contexts, making it a complex web of interactions between various regions of the nervous system beyond simply the primary motor area. Normal functioning depends on other areas such as sensory/perceptual abilities, cognitive function, visual capabilities, and postural control, among others. Ascertaining the optimal placement of the device or device features for access is dependent upon finding a region which provides a consistent, accurate, and controlled response. The individual should be able to utilize a device without undue hardship with the intention of initiating and completing an action.

Category 18 was *Range of Movement*, and contained only one subcategory, *Range of Motion.* This subcategory was found to be important to the assessment process and was vigorously endorsed by many of the expert panelists, with one going so far as to state that this area needs to be evaluated prior to any consideration of a device. Once again, many of the other areas that have been deemed important to the assessment have an effect upon this area (e.g., increased muscle tone or spasticity causing shortening of the muscles and eventually joint contractures). There needs to be some method to interface with the device, and without adequate movement, alternative modes of access may be required. It is obvious that this element will affect where an AT device is placed because of limitations in movement. The importance of assessing not only the extremities, but also head and trunk movements may not be readily apparent to those performing the assessment. For example, orientation or attention may be affected if there is restricted range of motion or contractures of the cervical spine. This will affect the positioning of a device for easy access, and visually guided movements. A detailed exam and reporting in this area can have a significant impact on the efficacy of the AT intervention.

Category 19 looked at the importance of *Posture* with three subcategories—*Scoliosis or Kyphosis, Postural Stability,* and *Postural Support*. All of these categories were felt to be important to the assessment, with a moderate degree of consensus, except for *Scoliosis or Kyphosis*, which scored slightly below the benchmark of 80% for ranking this element as "very important" or "important" to the assessment. There were various comments offered attesting to how critical these subcategories were. If an individual is not positioned in a manner in which he/she is upright and comfortable, this can affect areas such as perceptual input (e.g., visuospatial orientation). This category may be one that should have previously been accommodated for according to some respondents. However, it is still an area that must be examined to screen for additional problems that may impact the ability to access a computer. There should be enough knowledge of this area to at least consult a specialist. To some, this area is a perquisite to addressing any of the other assessment areas. Many individuals with severe disabilities have impaired postural control for a number of reasons, whether it is weakness, deformities, or impaired position sense. If a person is not sitting upright, attention is another area that can be affected. A majority of the expert panelists concede that positioning is a vital precondition to further assessment Yet, it appears that many believe that this area should already have been addressed before an individual was referred for the AT assessment. It is my personal opinion that since this area is so critical to the assessment, it is necessary when implementing the assessment to ascertain if there are any difficulties with postural control or positioning needs before proceeding with suggestions for AT devices.

Category 20 was labeled as *Team Approach*, and had two subcategories, *Collaboration* and *Qualified Team Members*. There was a high level of consensus for inclusion of this area in the assessment of computer access. None of the respondents rated this as a category that should not be included in the assessment. There were suggestions that no one person is an expert in AT, and that a team approach is imperative. The assessment process is implemented when recruiting members of the team. The expert panel articulated that the team should be qualified, and not only should the members know what is involved in their specialties, but should have training in the field of AT, although a certification does not assure competence. This area has figured prominently in the literature on AT, with a recurring theme that collaboration by the team members is of primary importance, otherwise there is often failure of the intervention. Another principal finding in the literature comparable to the findings in this study is that the majority of AT professionals advocate a team approach, but this is not always a realistic scenario in the field of AT. The team must function as a coherent unit, stressing the importance of input from all persons, although someone needs to coordinate the process. Judging by these conclusions, this area will become an important aspect of AT service delivery with attention to how collaboration can be improved. Other modes that may facilitate the process such as distance collaboration via e-mail, chat, web conferencing, or project sharing software may be options that should be explored.

Category 21 concerns the *Environment* and consists of two subcategories, *Environmental Assessment* and *Trials in the Environment*. There was a high level of consensus with most of the respondents considering this area as one that was very important to the assessment. A person must be cognizant of the manner in which the device is used on a day to day basis, which is the key to prolonged use of a device. Many of the experts throughout the survey mention that the assessment should be tied to an individual's function. It is difficult to truly assess function without knowing in what contexts these functions will occur. The abilities of the person do not necessarily transcend settings, and may not be generalizable to other environments. There are different task requirements depending upon the environment, whether at school, home, or work. Difficulties may arise when attempting to satisfy this area due to constraints on time or resources, yet simulated environments for task analysis may be an adequate substitute and should warrant consideration in the estimation of some experts.

The last category (22) deals with *Trials/ Devices* consisting of the subcategories *General Computer Competencies, Input devices, Output Devices, Device Flexibility, Compatibility, Technical Support, Family or Support Personnel,* and *Affordability*. All of the subcategories were judged as necessary for an assessment except *General Computer Competencies* and *Affordability*. Moreover, *Input devices* and *Output Devices* were seen as areas that are the motive for the referral and evaluation in the first place. Unfailingly, the team would always incorporate one or both of these elements into any assessment for AT for computer access along with the proper software if needed. Most of these elements had a moderate to high level of consensus. Some individuals felt that this area was intended for implementation rather than part of the assessment, but rated these areas as important to the assessment anyway. There were several respondents who said that all of these areas relating to the device, with the exception of *Affordability* and *Computer Competencies,* revealed why a team approach is needed. Therefore, none of the areas should be left out of the assessment. These elements should conclude the assessment process to initiate the trials of the device. Meticulous data collection should be instituted at this phase of the assessment regarding device trials in order to justify the use of the AT device or make changes if necessary with input from all of the team members. One of the respondents included *follow-up* as a suggested subcategory for the assessment. I believe for a complete assessment this needs to be included, although some may not think that it is a component of the assessment. The needs of the individual will change over time, requiring modifications or enhancements. The areas in this category are perchance the most time consuming, due to the need for extended trials and myriad of devices from which to choose.

Significance of the Findings

U.S. Public Law 100-407 defines an assistive technology service as "any service that directly assists an individual with a disability in the selection, acquisition, or use of an assistive technology device" (Council for Exceptional Children, n.d.; Minkel, 2002). The assessment process is likely the most consequential phase in the provision of assistive technology services. The AT device should be issued only after a comprehensive approach to assessment has been implemented by a team of qualified individuals that is an accurate assessment of the person's abilities in their specific environment. Without an effective assessment, failure of the technology to provide any demonstrable benefit is practically assured. It is difficult to justify any form of AT service or device without a standardized paradigm to determine if the instruments being utilized are valid. The assessment process should be comprehensive in its scope, and universal in its use and acceptance by those in the AT field.

As the use of AT to enhance the lives of persons with disabilities evolves, and the field of AT expands, there will be heightened scrutiny from those involved in providing support and funding for these devices. Edyburn (2003) discusses a trend toward greater accountability in the field of AT in order to appraise the value of technology and its impact on persons with disabilities. Currently, three research entities are studying the effectiveness of AT measures. The Office of Special Education Programs (OSEP) supports the National Assistive Technology Institute based out of the University of Kentucky to implement practice guidelines to improve services. The Assistive Technology Outcomes Measurement System (ATOMS) and the Consortium for Assistive Technology Outcome Research (CATOR) are sponsored by the National Institute on Disability and Rehabilitation Research (NIDDR) to assess outcomes in AT provision. By utilizing data on what interventions are the most efficacious in the field of AT, services can be rendered less haphazardly, using a more evidence-based approach. According to Edyburn, measuring the effectiveness of AT involves three distinct phases: exploratory phase (intuition or observation), descriptive phase (anecdotal evidence or case studies), and empirical phase (research studies). Contemporary practices for data collection in the field of AT utilize all three phases. In another article Edyburn (n.d.) reports on the sheer enormity of available AT devices, making it difficult to track outcomes. There are also a number of perspectives and contexts by which the technology can be judged as successful or not, depending on whose point of view you entertain (i.e., that of the user or person providing the device). However, determining the effectiveness of the AT device involves more than just the device, it also encompasses the AT services. There are a number of areas that can be measured when judging outcomes including:

1) Change in performance/function (body, structure, activity)
2. Change in participation
3. Usage and why or why not
4. Consumer satisfaction (process, devices)
5. Goal achievement
6. Quality of life
7. Cost
8. Demographics
9. AT interventions (services & devices)
10. Environment context

(Edyburn, n.d)

Hall, Doe, and Noakes (n.d.) rated the influence that AT has had on the quality of life for persons with disabilities. These individuals rated their quality of life on a scale of 1-10 related to the use of AT. Individuals estimated their quality of life as a 3 without AT, and an 8.4 with AT. However, every individual has unique needs that are the most applicable to them on a personal level. “Since appropriateness is extremely individualistic, assessment is a key component” (Hall, Doe, & Noakes, ¶ 61). The multidimensional character of AT provision engenders consideration of many factors that can limit the utility of the device, leading to abandonment if all facets are not explored. Doe and Noakes (n.d.) maintain that if you are not able ensure the “proper fit” of the technology to the individual, the technology is commonly rejected. Movement toward a user-centered or consumer-centered model is warranted. Insuring that the individual being assessed is the focus of the research should encompass evaluating environmental factors and the individual’s level of independence, in lieu of the traditional medical or rehabilitative emphasis.

Recommendations for AT Assessments

Legislative measures have been instituted that mandate accommodations for individuals with disabilities to enhance their ability to participate in various aspects of society. The government recognizes disabilities as a normal part of the life experience, and individuals have equal rights for inclusion in society that can be promoted by the use of technology. As with any type of societal intervention based on governmental legislation, there needs to be an accurate assessment of need in order to suitably fulfill the obligation to provide the best services possible. In the field of AT this involves a complex network of service providers requiring input using a team approach from a variety of persons with disparate training and expertise. Especially problematical with regard to the assessment process are those persons with severe disabilities, frequently individuals with neurological conditions. The intricacy of the nervous system presupposes the complexity of the assessment of these individuals.

At the very least, individuals on the AT team should possess a cursory knowledge of the conditions that cause neurological deficits and their manifestations. This is elemental to performing an accurate assessment. One must be able to discern a number of impairments that may be encountered in someone with a neurological condition. By employing both input and output signals in the CNS, humans control cognitive, sensory, and motor functions in order to exist and interact with the environment. Motor control occurs at many levels of the brain, and is intimately linked to cognitive and sensory functions. Therefore, motor impairments are more complex than mere weakness or paralysis. This area requires careful assessment in order to design an AT intervention for computer access commensurate with the person’s abilities. Motor control, ranging from automatic to planned or volitional movements, can be altered secondary to a number of different factors. For example, perceptual or cognitive deficits can affect the ability to execute a task, such as operating a computer. Common movements such as reaching are extremely complex, and require careful observation in order to determine what type of input devices can be utilized to enable some mode for computer access. Another component of movement is the precondition that stability or equilibrium of the body be maintained to allow controlled or coordinated motor activity. If an individual cannot sustain an upright posture, then he/she will be unable to move in a typical manner. Furthermore, inaccurate or atypical sensory input from the environment (e.g., impaired visuospatial orientation) may occur due to faulty posture. This needs to be accommodated for or corrected using special seating or positioning devices, and will affect placement of input and output devices relative to individual's orientation in space.

Information regarding a medical condition and its onset (i.e., prenatally, infancy early childhood, adulthood) will also aid in the assessment. This information can be obtained from the medical record or family. There are distinct impairments that arise from different medical conditions that should be noted in the assessment, whether they are primary (directly due to the condition) or secondary (a condition resulting from the primary impairment). Furthermore, particularly in persons with brain injury, multiple impairments are often exemplified. The four major categories of impairments occurring in brain injuries that are relevant to the assessment for computer access are: (1) sensori-motor, (2) behavior, (3) communication, and (4) cognitive deficits, and can be encountered in any combination.

The sensory system is another facet of the AT assessment that must be explored in detail in order to complete the AT assessment. The ability to perceive one's internal and external environments is critical to the performance of a goal directed task. If there is anomalous input to the nervous system, the result will be an impaired ability to generate the necessary reactions to execute a task. The ability to move and direct ones attention to perform a task is highly dependent upon sensory input. In certain contexts movements are pre-planned contingent upon sensory input providing continual feedback. Auditory input or sound may not be perceived, or may not be decoded or represented properly in the brain. By neglecting to assess for deficits in hearing, accommodations using more visual types of stimuli may be overlooked. Visual inputs are critical for selecting input and output devices or software for computer access. However, similar to hearing, acuity may not be the problem, but the inability to process visual input or loss of vision in one part of the visual field could occur. This may not be noticed unless there is a comprehensive assessment.

Cognition is another area that should be incorporated into the assessment for computer access. Sensory and perceptual inputs, memory, attention, and various other factors coalesce to define cognition. Cognition denotes the ability to reason in order to execute some type of goal-directed function. A substantial aggregation of information is processed by an individual's CNS in order to execute both conscious and unconscious acts. There is a need for conscious intent in order to plan an action, although some tasks eventually become automatic. Any disturbance in cognitive ability can significantly limit the ability of the person to interface with the computer. Complex operations may not be feasible, and the individual may require adaptations to simplify the mode of access to the computer. The ability to plan and execute tasks will impact access to a computer at all levels, and if an individual does not have this capability, prompting or cueing with AT devices may be necessitated.

Neuropsychological deficits can be classified into three distinct categories: mood, behavior, and cognitive disorders. There may be cognitive deficits, memory impairments, language difficulties, limitations in executive function, and decreased awareness. Mood or behavior disorders can be a primary occurrence, or develop secondary to conditions such as cognitive deficits. Some of the impairments noted are agitation, anxiety, or depression. All of these can affect the ability of the individual to use a device. For instance, an elaborate input device such as a standard (QWERTY) computer keyboard may easily frustrate an individual with a cognitive disorder. Attention or awareness deficits can also be impediments to effectively accessing a computer. An individual may be unable to concentrate, attend to multiple tasks, or filter out irrelevant stimuli. These problems with attention could impede the ability to execute repeated tasks or sustain a task. Memory is also important for carryover to implement tasks. The ability to discriminate the stages involved in completing an action will allow a person to perform tasks of increasing complexity. An individual must also have the capability to monitor their activities, making changes as required depending upon the context or current demands that are being placed on him/her.

As was mentioned earlier in the study, a symptom represents a functional deficit due to a condition or disease. In essence, the functional abilities of an individual are what you are determining when implementing an assessment. There is substantial variability in the presentation of impairments between individuals, particularly in severely disabled persons. With movement dysfunctions you may observe either restricted or excessive motion, and you must select the most suitable device based on your findings in the assessment. Coordination deficits, balance problems, abnormal muscle tone, impaired sensory input, decreased level of alertness, and cognitive deficits are just a few of the components involved in movement disorders that impair accessibility for computer input. Diminished, abnormal, or absent sensation or perception can also independently affect what type of AT device should be selected. Spatial perception, spatial neglect, and depth perception are all deficits that may occur and need to be recognized. A careful assessment of deficits should reveal what accommodations will be needed to allow compensatory strategies.

There are deficiencies that have been observed in the assessment process for computer access. The manner in which the assessment is conducted with poor procedural guidelines is a significant problem according to the QIAT symposium. The assessment should be conducted by a qualified, multidisciplinary team with key involvement from the individual or his/her family in the pertinent environments. The goals for using the technology should be agreed upon by the family and the assessment team. The team must collaborate effectively for a quality assessment, and allot the necessary time to conduct a thorough assessment including device trials. The assessment should reflect the resources available to support the individual, including family involvement. Furthermore, the demands that the technology will place on everyone involved with the individual being prescribed the device should be given scrutiny. This will enable proper planning and technical decisions to be made. The fact that the person receives a device does not ensure that he/she will use it. There needs to be an assessment of social attitudes surrounding the person to determine if an AT device will be accepted in the environments that it will be utilized.

Bromley (2001) studied the various assessment models finding that many use a person's unique environment, and prioritize the needs of the individual in his/her particular environment. The models also stress the need for a multidisciplinary, collaborative approach within a functional assessment. An important paradigm mentioned throughout the literature was the seemingly omnipresent SETT model (also amenable to non-educational settings). This acronym denotes the **S**tudent, **E**nvironment, **T**asks, and **T**ools. These categories depict the intrinsic characteristics of the student (sensorimotor, communication, behavioral, and cognitive), the environment or contexts in which they will be functioning, the tasks that he/she will be attempting to carry out, and the tools denoting the devices (input, output, and software). Addressing all of these categories will assist in accomplishing the goals of the team and the individual. The devices and how they will be used is a product of the initial assessment, which is ongoing. Follow-up is crucial and should continue indefinitely. Some believe that the assessment ends with the prescription of the device, but the abilities of individuals are not static, and these fluctuations, whether positive or negative, need to be addressed. A reassessment can include all or some of the areas in the assessment instrument. In particular, persons with severe and multiple problems with CNS disorders will necessitate more frequent monitoring.

When assessing persons with neurological deficits, especially severe impairments, the complex nature of this undertaking should be acknowledged. There is a lack of assessment tools that accommodate for the complex array of cognitive, linguistic, memory, attentional, sensory and perceptual, motor, and psychosocial problems inherent in this population. The environment in which the person resides is also a necessary consideration. As Babbage and Leathum (2000) illustrated in their research, persons with the most severe impairments and multiple disabilities are the most difficult to assess, and presently valid assessments are lacking.

Peripheral devices (both input and output) and software need to be adapted through careful assessment and trials in order to compensate for physical and mental deficits, taking into account external factors such as the environment or available support. Through research and trials we can continually improve the assessment process in multiple areas. Additionally, collaboration with other team members, the person being assessed, and his/her family or caregivers will improve the testing and outcomes in the most severely affected individuals. However, there is so much variability in the population being assessed, that we should consider the assessment to be a guideline, and extend or tailor the process according the person's needs. An example would be specific measures that assess functions such as visuoperceptial abilities if this is thought to be a significant problem. Ultimately, the least complicated mode for computer access should be utilized by the individual. By using the device that provides the most efficient and effortless method for access, the person should be able to readily access a device and use it for its intended purpose. Extended trials and training of the individual, family, teachers, caregivers, and significant others will complete the assessment, and is the only way to truly discern if the assessment has been accurate and complete.

The Tech Connections Audio Conference (2002) proposed models such as the HAAT model, linking the computer and human interface. This model integrates all the elements that have been discussed as fundamental to the assessment process, and links them to using the computer in a variety of contexts. This matches the technology to the person, and facilitates access based on his/her abilities. The AT intervention is successful when sensory, motor, and cognitive factors are evenly matched with the input and output devices and operating software. The input device, output device, or software is assessed for various placement sites, the optimal settings, and access features. An example would be choosing an input device with direct access (e.g., adapted keyboard) or indirect access (e.g., scanning using an onscreen keyboard using a switch).

Before the assessment can be judged as valid, it may be beneficial to have a protocol with criteria that will allow the AT practitioner to judge the completeness of the instrument that they are implementing. Studies outlining the elements that should be included can aid in standardizing the assessment process. This study developed a list of elements (Table 4) utilizing a review of the recent literature and a Delphi study of experts in the field. Other similar studies may be able to modify this list and further promote the development of relevant items that should be incorporated into a quality assessment instrument.

Implications for Further Research

The fledgling field of AT has been portrayed as devoid of evidence-based practice according to much of the contemporary literature on this subject. To attain a goal of evidence-based practice, the assessments by AT professionals must be analyzed with an eye toward standards that are validated by researchers and practitioners in this evolving field. This study examined in detail the elements that should be incorporated into assessments for computer access, assigning particular emphasis to assessments for persons with severe neurological disabilities. The intent was to gain insight into the needs of a population that is likely underserved due to the complexity of their conditions, and the lack of understanding of their impairments. We are still learning the causes and manifestations of many of these conditions. Based on new evidence from research in the fields of neuroscience, rehabilitation, and education, we can improve the assessment of persons requiring AT interventions that will improve his/her functional abilities.

Neuroscience has contributed to our knowledge base regarding how the brain functions and the consequences of lesions of the brain. It is virtually certain that there will be a neurological component involved in those persons with severe disabilities. Persons with head injuries or damage to the cerebral cortex are especially prevalent in the severely disabled population. Hence, the need for knowledge regarding how these individuals will be affected by his/her condition. The field of rehabilitation gives us methods for assessing deficits that may be present in persons with neurological problems, and what types of accommodations or interventions may assist in helping improve the functional abilities of these individuals. Contributions from the discipline of education enable the assessment of persons relative to how disabilities such as head injuries impact learning and activities of daily living. All of these disciplines will continue to augment the available literature related to computer access through research and practice.

There are relatively few extant measures that are valid and reliable methods to assess the impairments of persons with severe neurological deficits. Thus far, there are relatively few guidelines for conducting an assessment. This study will aid in determining a set of criteria for the inclusion of specific elements in an assessment by reviewing the literature and procuring information from those considered experts in the field. In the Delphi study there was a moderate to strong consensus by the expert panelists for inclusion or exclusion for most of the areas developed for the survey relating to the assessment of individuals with disabilities for computer access. There are many assessment instruments currently being utilized, and one may not be necessarily better than another. The assessments listed in the Appendix B cover a variety of areas, but do not represent all of the elements that were found to be critical to an assessment for computer access. There should be parameters by which an assessment instrument or model can be evaluated to determine if it is a comprehensive and valid tool. Many of the assessment measures currently in use do not promote a collaborative assessment with consideration given to all of the areas that may have ramifications affecting the use of an AT device. Not every individual will need an assessment that includes all of these elements. However, all of the areas should at minimum be ruled out as having an impact on the successful utilization of an AT device. The merit of the assessment hinges upon the qualifications of the team and how well they collaborate during the process. It is incumbent upon the team leader to attract individuals to the assessment team with experience and knowledge, and the capability to research elements that are thought to be critical to the assessment for computer access using AT.

Further studies may research the assessment procedure as a whole, or parts of the process. One other study that focuses exclusively on the assessment process and the elements that should be incorporated into an evaluation for computer access using AT has been identified through a search of the literature. This area should doubtlessly be researched further. Additional study in the realm of computer access may also be valuable for other types of AT assessments such as those for learning, communication, environmental access, etc., utilizing computerized technology. There are categories that may have been excluded from this synthesis or others that may be redundant or unnecessary.

This was a study that did not restrict persons from participating based on years of experience, but looked at persons who work in the field with specific credentials or have published in the literature. There may be something to gain by defining a population of respondents based on their experience level in order to set stricter standards for inclusion in the study. Moreover, in the future there may be an officially recognized certification for AT professionals, possibly in different specialties of AT, that may allow a study using experts with the greatest experience and knowledge of a particular area of AT (e.g., computer access). The results of this study and other comparable studies may be used as a criterion-referenced approach to determining the utility of assessment instruments using the elements that were judged as important to the assessment process as criteria. The study may also be utilized to develop specific instruments that are predicated upon information gleaned from the literature review and experts in the field of AT. Further study may heighten the ability to determine the construct validity of using criteria developed by selected experts in the field of AT to measure the quality of the assessment instrument. Other research may be conducted which utilizes outcome measures to establish the efficacy of assessment instruments that contain the elements that are considered essential to the assessment of individuals for computer access. This will further validate the results of this and other studies, and the usefulness of a criterion-referenced approach to judge the validity of a particular assessment methodology. This may be accomplished in a variety of ways. The success of the AT device prescribed for an individual can be determined by researching variables such as the level of abandonment, perceived satisfaction using the device, goal attainment, ability to perform a specified task, or some other form of quantitative or qualitative data analysis. Another option may be randomized controlled studies of specific populations comparing assessment instruments and various interventions, and the outcomes of these interventions. Studies that define more specialized assessments within the purview of computer access may also be conducted. For example, there may be guidelines that are more appropriate for use in pediatric populations as opposed to adult or geriatric populations. As new information about the effects of brain injury and other conditions that may be amenable to adapted computer access is accumulated, in concert with the evolution of new technologies, further studies will be warranted in order to foster continued refinement of the AT assessment for computer access. LoPresti, Koester, and McMillan (n.d.) describe efforts to develop assessments of persons for computer access skills in different areas with automatic data recording and ratings of these skills. Utilizing an electronic means for assessment may utilize data from studies such as this one to develop categories for measuring certain skills and levels of proficiency when an individual using AT devices performs specified tasks.

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APPENDICES

Appendix A- ACES Assistive Technology Services Referral Form

aces

Area Cooperative Educational Services
Assistive Technology Services Referral

Student's name:	**DOB:**	**Date:**
School system:	**School:**	**Grade:**
Teacher:	**Phone:**	**Fax:**

Parent's name:	**Address:**	**Phone:**

Person(s) completing this referral form:			
Designated contact person:	**Title:**	**Phone:**	**Fax:**

Assistive Technology is the provision of service, training, and/or assistive device utilized as a method to meet the specific objectives within the student's Individual Education Plan (IEP) and/or 504 plan. A collaborative team process is suggested in compiling this referral information pertinent to the assistive technology assessment.

Disability: [check all that apply]
__Neurological Impairment __Cognitive Impairment __Learning Disability __Speech/Language __Hearing Impairment
__Vision Impairment __Traumatic Brain Injury __Emotional Disturbance __Autism __Respiratory Compromise
__Seizures __Orthopedic Condition __Degenerative Medical Condition __Other:______________
__Precautions (e.g., Seizure Protocol, Behavioral Protocol):______________________________

Related Services Received	**Frequency/Duration**	**Provider**
Occupational Therapy		
Physical Therapy		
Resource Teacher		
Speech/Language Pathologist		
Social Work		
Psychology		
Nursing		
Other		

Current Assistive Technology Used [complete all applicable sections]

Assistive Technology Device	**Type** and/or **Manufacturer/Model** and/or **Platform/Operating System**	**Features** (e.g., screen enlargement, voice output, special switches, word prediction)
Computer		
Manual Communication Board		
Augmentative Communication Device		
Vision Aids		
Amplification System		
Manual Wheelchair		
Power Wheelchair		
Adapted Classroom Chair		
Ambulation Aids		
Alternative Positioning Equipment		
Writing Aids		
Environmental Control/Adapted Toys		
Educational Software		
Other		

Check educational strategies, modifications, and/or "low" technology implemented:

__Directions modified or simplified	__Enlarged or bold print	__Heavy or raised line paper
__Assignments shortened	__High contrast	__Scanning of text
__Highlighter *or* marker *or* template *[circle]*	__Manipulatives	__Adapted desk *or* tray *or* table *[circle]*
__Tape recorder *or* taped text *[circle]*	__Transcription by others	__Preferential seating
__Verbal response instead of written response	__Slant board or easel	__Adapted writing implements *[type]*______
__Pointing/gestures instead of written response	__Talking calculator	__Spoken text to accompany print
__Graphics to communicate ideas	__Talking dictionary/spell check	__Other(s)

The student can: [Check all that describe the student's abilities]

__Concentrate on task consistent with age	__Interact appropriately w/peers	__Request communication clarification
__Concentrate within a distracting environ.	__Initiate social interaction	__Perform without verbal prompting
__Make appropriate eye contact with speaker	__Ask questions	__Perform without physical prompting
__Display age-appropriate listening skills	__Follow modeled directions	__Make choices when objects/activ. presented
__Make appropriate eye contact with task(s)	__Follow simple auditory direc.	__Understand the consequences of own actions
__Respond to communication interaction(s)	__Follow multiple step direc.	__Complete a task independently

Communication [Check all that describe the student's present methods of communication.]

__Speech __Intelligible __Age appropriate __Single words __Phrases __Sentences __Partially intellig. __Word approx.	__Commun. board or notebook using: __Objects __Pictures __Words __Symbols # used:____ size:____	__Electronic communic. device using: __Objects __Pictures __Words __Symbols __Voice output # used:____ size:____	__Computer software using: __Objects __Pictures __Words __Symbols __Voice output __Typing __Other__________	__Sign __ASL __SEE __Sign approx. __Symbols __Voice output Approx. # used:____
__Eye gaze/movements	__Facial expressions	__Gestures	__Pointing	__Handwriting
__Indicates "yes" __Consistent __Unable __Not reliable __Inconsistent __Method__________	__Indicates "No" __Consistent __Unable __Not reliable __Inconsistent __Method__________	__Reliable ability to communicate basic needs to: __all __family/caregiver __peers __no one	__Typing	__Other__________ __________ __________ __________ __________ __________

	Age Approximation	Indicate name of formal test(s) *or* method of informal testing
Receptive Language		
Expressive Language		

Visual Skills Related to Communication and Academics [Check all that describes the student's abilities]

__Can maintain fixation of stationary object/picture	__Recognizes common object(s)	__Has visual-perceptual deficits
__Can look to right/left without moving head	__Recognizes symbols or pictures	__Can read if text enlarged to:____
__Can visually shift horizontally and/or vertically	__Recognizes familiar people	__Unable to read text
__Can scan symbols left to right	__Recognizes photographs	__Requires high contrast
__Can scan a matrix of symbols in a grid	__Lighting impedes vision	__Uses screen enlargement device
__Preferred object placement:__________	__Wears corrective lens	__Uses screen enlargement software
__Benefits from special lighting:__________	__Uses only one eye: __right __left	__Uses taped or talking materials
__Tilts head when reading or scanning	__Requires materials tilted	__Can read standard textbook print

	Grade Level *or* Age Approximation	Indicate name of formal test(s) *or* method of informal testing
Reading		
Math		
Spelling		
Cognitive (Verbal)		
Cognitive (Performance)		

Pre-reading and Reading Skills [Check all that describes the student's abilities]

__Displays object/picture recognition	__Displays sight word recognition
__Displays symbol recognition (e.g., Mayer-Johnson, Rebus)	__Requires graphics *and/or* symbols *[circle]*
__Follows modeled directions	__Requires spoken text to accompany print
__Follows simple written directions	__Requires bold type or highlighting for main ideas
__Follows multiple step directions	__Requires enlarged print
__Displays auditory discrimination of sounds	__Requires reduced text on page
__Displays auditory discrim. of words *and/or* phrases *[circle]*	__Can decode words *and/or* sentences *[circle]*
__Recognizes shapes, colors, numbers, *and/or* letters *[circle]*	__Can decode worksheets, books, *&/or* text on monitor *[circle]*
__Selects initial letter/sound of word	__Can comprehend meanings of written text

Writing **Current Writing Abilities** [Check all that describes the student's abilities]

__Can hold regular pencil	__Can print name	__Requires soft lead pencil
__Can hold pencil adapted with:__________	__Can write in cursive	__Requires felt tip pen *or* marker *[circle]*
__Can hold a pencil but unable to write	__Can write on narrow lines	__Writing is slow and tedious
__Can print a few letters *and/or* words *[circle]*	__Can write on 1" lines	__Writing is limited due to fatigue or endurance
__Can copy simple shapes	__Can use spacing correctly	__Can write independently and legibly
__Can copy words from worksheet/book	__Can write approp. size	__Generates ideas using symbols *or* objects *[circle]*
__Can copy words/sentences from board	__Requires raised line paper	__Can generate sentences
__Tends to skip letters when copying	__Requires bold line paper	__Can generate paragraphs

Current Keyboarding Abilities [Check all that describes the student's abilities]

__Does not currently type	__Can activate desired key	__Uses switch to access computer:__________
__Types slowly with one finger	__Types slowly using more than one finger	__Uses alternative keyboard:__________
__Accidentally hits unwanted keys	__Types with ten fingers	__Uses software to access computer:__________
__Needs arm or wrist support	__Uses Touch Window	__Other computer access method:__________

Current Computer Use [Check all that apply]

The student uses a computer:	__never	__at school	__at home	__word processing	__games	__other
The student received computer training:	__never	__keyboarding __internet	__word processing	__operating system __file mgmt.	__computer access	__educ. software

__The student has access to a computer at school with the following: [Describe: Windows/Macintosh platform; operating system; special components; software]____________________

__The student has access to a computer at home with the following: [Describe:Windows/Macintosh platform; operating system; special components; software]____________________

Team's intended focus of assistive technology service:

__Communication **__Computer access** **__Software selection** **__Mobility**
__Vocational **__Environmental Control** **__Seating/Positioning** **__Educational Strategies**

AT Services Requested

__Evaluation
__Training
__Consultation

List the questions you want addressed by an assistive technology assessment/referral.

1)____
2)____
3)____
4)____

List the IEP objectives that assistive technology would address.

1)____
2)____
3)____
4)____

What is the team's anticipated educational outcome of using AT in relation to the IEP objectives?

1)____
2)____
3)____
4)____

What is the student's anticipated educational outcome of using assistive technology?

____

____

What are the environments and educational routines that are difficult for the student?

1)____
2)____
3)____
4)____

Is the student expected to transition to a new environment? When? What demands will this pose?

____

____

____

****

1) Use the attached form to obtain the family's input regarding this evaluation or consultation.
2) Include the following evaluations and reports with this <u>referral form</u>:

__Current IEP __Occupational Therapy (required if services received)
__Educational __Physical Therapy (required if services received)
__Psychological __Speech/Language (required if services received)
__Social Work __Vision (required if services received)
__Nursing __Medical reports; type(s)____

Appendix B- Examples of Computer Access Assessments

WATI Student Information Guide
SECTION 1
Fine Motor Related to Computer (or Device) Access

1. Current Fine Motor Abilities

Observe the student using paper and pencil, typewriter, computer, switch, etc. Look at the movements as well as the activities and situations. Does the student have voluntary, isolated, controlled movements using the following? (Check all that apply.)

❒ Left hand	❒ Right hand	❒ Eye(s)
❒ Left arm	❒ Right arm	❒ Head
❒ Left leg	❒ Right leg	❒ Mouth
❒ Left foot	❒ Right foot	❒ Tongue
❒ Finger(s)	❒ Eyebrows	❒ Other ________

Describe briefly the activities/situations observed________________________________

2. Range of Motion

Student has specific limitations to range. ❒Yes ❒No

Describe the specific range in which the student has the most motor control.________________

3. Abnormal Reflexes and Muscle Tone

Student has abnormal reflexes or abnormal muscle tone. ❒Yes ❒No

Describe briefly any abnormal reflex patterns or patterns of low or high muscle tone that may interfere with the student's voluntary motor control.________________

4. Accuracy

Student has difficulty with accuracy. ❒Yes ❒No

Describe how accurate, reliable and consistent the student is in performing a particular fine motor task.

5. Fatigue

Student fatigues easily. ❒Yes ❒No

Describe how easily the student becomes fatigued.____________________________________

____

____

____

6. Assisted Direct Selection

What type of assistance for direct selection has been tried? (Check all that apply.)

❒ Keyguard ❒ Head pointer/head stick

❒ Pointers, hand grips, splints etc. ❒ Light beam/laser

Other:____

Describe which seemed to work the best and why.____________________________________

____

7. Size of Grid Student Is Able to Access

What is the smallest square the student can accurately access? ❒ 1" ❒ 2" ❒ 3" ❒ 4"

What is the optimal size grid? Size of square__________

Number of squares across__________

Number of squares down__________

8. Scanning

If student cannot direct select, does the student use scanning?

❒ No

❒ Yes, if yes ❒ Step ❒ Automatic ❒ Inverse ❒ Other________________

Preferred control site (body site)______________________________________

Other possible control sites____

9. Type of Switch

The following switches have been tried. (Check all that apply. **Circle the one or two** that seemed to work the best.)

❒ Touch (jellybean) ❒ Light touch ❒ Wobble ❒ Rocker

❒ Joystick ❒ Lever ❒ Head switch ❒ Mercury (tilt)

❒ Arm slot ❒ Eye brow ❒ Tongue ❒ Sip/puff

❒ Tread ❒ Other____

Summary of Student's Abilities and Concerns Related to Computer/Device Access

____

____

____

____

Waters, S. Computer Access Protocol. Georgia Project for Assistive Technology. http://gpat.org/compaccess.doc

COMPUTER ACCESS EVALUATION

Student Name: ______________________ System: ______________________
Date of Assessment: ______________________

Input: Keyboard and Keyboard Alternatives
Informal measures were used to evaluate the student's access/input skills. The following is a summary of his/her performance:

_____ Student could use the standard keyboard without adaptations
Method of access: _____ Left hand Fingers utilized: ______________
_____ Right hand Fingers utilized: ______________

_____ Student could utilize the standard computer keyboard when provided with these adaptations:
_____ Keyguard _____ Finger guard/pointer _____ Keyboard reconfiguration
_____ Wrist/arm support _____ Head pointer _____ Mouthstick
_____ Tactile locator dots _____ Other - Specify ______________
_____ Bold key labels

Using the standard computer keyboard with or without adaptations, the student:

Could identify alphanumeric keys	_____ Yes	____ No
Could identify function keys	_____ Yes	____ No
Could activate two keys simultaneously	_____ Yes	____ No
Could activate/deactivate key without causing key repeats	_____ Yes	____ No
Could activate keys without looking at keyboard	_____ Yes	____ No

Typing speed Specify words per minute _______

Specify any keyboard utilities used by the student (e.g. stickykeys, slow keys, etc.) and describe student performance:

_____ Student could not effectively utilize the standard keyboard with or without adaptations. The following keyboard alternatives were used by the student during this assessment:

____ Alternative keyboards
_____ Expanded keyboard _____ Miniature keyboard
_____ One handed keyboard _____ On-screen keyboard
_____ Touch Window _____ Stand-alone number pad

Specify specific use of keyboard alternatives used and describe student performance with each:

____ Microswitch access
The following switches were used during this assessment:

Switch	Activation Site	Location/Mount	Hold/Maintain	Release	Reactivate	Software Used

Switch access mode(s) used by the student:
___ Single switch access ___ Visual scanning ___ Auditory scanning
___ Combination

Types of scanning used by the student:
___ Directed (step) scanning ___ Linear scanning
___ Row/column scanning ___ Other, Specify ___________________

Additional comments regarding switch access:______________________________________

____

_____ Voice dictation system

Is student's speech consistent in enunciation of single words, words within a sentence and with volume?_ _____ yes _____ no

Does the student have the necessary breath support to speak single words within a sentence?
_____ yes _____ no

Can the student read well enough to correct recognition errors? ______ yes ______ no

Specify voice input/dictation system used and describe the student's performance: ____________
____
____
____

Comments: ____
____
____
____

Input: Standard Mouse and Mouse Alternatives
Informal measures were used to assess the student's ability to use the standard computer mouse and/or mouse alternatives:

____ Student could utilize the standard computer mouse
____ Student could not utilize the standard computer mouse. The following mouse alternatives were used by the student during this assessment:

____ Trackpad ____ Trackball ____ Switch Adapted Mouse
____ Joystick ____ Mouse Keys ____ Touch Screen/Touch Window
____ Head controlled mouse ____ Mouse emulation

When using the standard computer mouse and/or mouse alternatives, the student could:

Feature	**Mouse**	**Mouse Alternative Specify:**	**Mouse Alternative Specify:**
Single click			
Double click			
Click and drag			
Use pull down menu			
Navigate around windows			
Select text in word processor			
Other Specify:			

Comments: ____
____
____

Output: Monitor, Printer, and Voice/Speech
Informal measures were used to evaluate the student's ability to access the computer display and speech output. The following is a summary of his/her performance:

____ Student could see information on the standard computer monitor without adaptations

____ Student could see information on the standard computer monitor with the following adaptations:
____ Text enlargement within application - Specify font size: ______________________
____ Text enhancement (e.g. bolding) - Specify: _________________________________
____ Text/screen enlargement software - Specify: ________________________________
____ Text/screen enlargement hardware - Specify: _______________________________

____ Student could not see information displayed on the standard computer monitor with or without adaptations

____ Student could hear/understand synthesized speech and other computer generated sounds and cues

____ Student could hear synthesized speech and other computer generated sounds and cues when sound was amplified (e.g., external speakers or headphones)

____ Student could not hear synthesized speech and computer generated sounds with amplification

____ Student could read the print from a standard computer printer

____ Student required Braille embosser/printer

Comments: ____
____
____
____

Basic Computer Operations
The student's ability to execute the following computer operations was informally evaluated

Turn computer on and off	____ Yes	____ No
Turn monitor on and off	____ Yes	____ No
Insert disk in disk drive	____ Yes	____ No
Eject disk from disk drive	____ Yes	____ No
Turn printer on and off	____ Yes	____ No
Retrieve desired program from on-screen menu	____ Yes	____ No

Comments: ____
____
____

Software/Hardware Evaluated
During this assessment the student had the opportunity to use several software programs and adaptive devices. The following is a summary of his/her performance:

Software/Hardware Evaluated: ____
Student Performance: ____
____
____
____

Software/Hardware Evaluated: ____
Student Performance: ____
____
____
____

Software/Hardware Evaluated: ____
Student Performance: ____
____
____
____

Software/Hardware Evaluated: ____
Student Performance: ____
____
____
____

Software/Hardware Evaluated: ____
Student Performance: ____
____
____
____

Recommendations

Based on the results of this assessment, the following recommendations are made for this student:

The student can benefit from using a computer with appropriate hardware and software to enhance access to his/her educational program. The computer can support student achievement and independence in the following tasks/activities/areas:

____	Basic reading skills	____	Reading comprehension	____	Spelling
____	Written expression	____	Math calculation	____	Listening skills
____	Verbal expression	____	Receptive language	____	Leisure/play
____	Functional academics	____	Vocational	____	Other - Specify: ____
____	Skill development (i.e., motor planning, scanning, etc.)				____________________

The most appropriate input technique(s)/tool(s) for the student at this time is/are:

____ Standard keyboard

____ Standard keyboard with adaptations - Specify: ______________________________
____

____ Keyboard alternatives - Specify: ____
____

____ Mouse or mouse alternative - Specify: ______________________________________
____

The following recommendations are made regarding the standard computer monitor, adaptations, and/or alternatives:

____ Standard computer monitor without adaptations

____ Standard computer monitor with the following utilities/adaptations: ________________________

____ Large monitor. The optimal size is _________ inches

____ Adaptive software/hardware in order to access the computer's visual output (e.g. screen magnification, screen reading, etc.) - Specify: ____
____

The following recommendations are made regarding the computer printer and/or alternatives:

____ Standard printer
____ Braille printer - Specify: ____

The student requires access to appropriate educational and/or access software. The following recommendations are made regarding software: ____
____
____
____
____
____
____

Specify any additional equipment needed: ____
____
____
____

Additional comments/recommendations: ____
____
____
____
____
____
____

Computer Access Evaluation Conducted by:

________________________________	____________________	______________
Name	Position	Date

Appendix C- Extended Assessments and Trials

Assistive Technology Extended Assessment Plan

Date of Extended Assessment Planning: ______________________

Student Data	Team Members
Student Name: ______ Parent Name(s): ______ Parent Phone: ______ Parent Email: ______ Parent Address: ______ ______ Date of Birth: ______ CA: ______ Disability: ______ IEP Date: ______ Medicaid ID# *(If applicable)* ______ Medical Diagnosis *(If applicable)* ______ Social Security # ______ Grade/Placement: ______ Student #: ______ School: ______ School Address: ______ ______ School Phone: ______	**AT Extended Assessment Coordinator** Name ______ Title ______ Phone ______ Email ______ **Other Team Members** Name ______ Title ______ Phone ______ Email ______ Name ______ Title ______ Phone ______ Email ______ Name ______ Title ______ Phone ______ Email ______ Name ______ Title ______ Phone ______ Email ______

Overall Goal for Device Use

Goal for Device:

____

How will we know if the trial is successful?

____

What level of achievement is reasonable to expect during the trial period?

____

How will we know if the trial is not working (What criteria will we use to stop)?

____

from: Education Tech Points: A Framework for Assistive Technology Planning

Customary Environments Where Devices Will Be Used

1. Environment: ______
   Tasks: ______
   Person responsible for implementation: ______
   Days to be used: ______
   Times to be used: ______

2. Environment: ______
   Tasks: ______
   Person responsible for implementation: ______
   Days to be used: ______
   Times to be used: ______

3. Environment: ______
   Tasks: ______
   Person responsible for implementation: ______
   Days to be used: ______
   Times to be used: ______

Specific Devices For Trial

Device #1 ______
Date of trial Initiation: ______ Minimum length of trial period: ______
Device trial review date: ______
Source of Device for Trial: ______
Contact person for technical assistance for trial: ______
Manufacturer: ______ Manufacturer technical assistance number: ______
Comments: ______

Device #2 ______
Date of trial initiation: ______ Minimum length of trial period: ______
Device trial review date: ______
Source of device for trial: ______
Contact person for technical assistance for trial: ______
Manufacturer: ______ Manufacturer technical assistance number: ______
Comments: ______

Device #3 ______
Date of trial initiation: ______ Minimum length of trial period: ______
Device trial review date: ______
Source of Device for Trial: ______
Contact person for technical assistance for trial: ______
Manufacturer: ______ Manufacturer Technical Assistance Number: ______
Comments: ______

 from: Education Tech Points: A Framework for Assistive Technology Planning

WATI Assistive Technology Trial Use Guide

AT to be tried:____

Student's Name: ____________________ DOB:________Age:__Meeting Date:______

School/Agency:______________________________ Grade/Placement:________

Contact Person(s):____

School/Agency Phone: ________________ Address: ______________________

Persons Completing Guide: ______________________________________

Parent(s) Name: ______________________________ Phone: ____________

Parent(s) Address: ____

Goal for AT use: ____

ACQUISITION

Source(s)	Person Responsible	Date(s) Available	Date Received	Date Returned

Person primarily responsible to learn to operate this AT:__________________________

Training

Person(s) to be trained	Training Required	Date Begun	Date Completed

WATI Assessment Package (2004)

MANAGEMENT/SUPPORT

Location(s)	Support to be provided (e.g. set up, trouble shoot, recharge, program, etc.)	Person Responsible

Student Use

Date	Time Used	Location	Task(s)	Outcome(s)

WATI Assistive Technology Trial Use Summary

Student's Name:______________________________Age:____Date Completed:__________

Person(s) Completing Summary: ____

Task Being Addressed During Trial____

Criteria for Success____

AT Tried	Dates Used	Criteria Met?	Comments (e.g. advantages, disadvantages, preferences, performance)

Recommendations for IEP: ____

Appendix D- Sample Letter of Introduction to Panel of Experts for Round One of the Delphi Study

Dear ________:

I have designed a research study pertaining to the assessment process for assistive technology for computer access in persons with disabilities, especially severe neurological conditions. This study has been instituted in order to fulfill the dissertation requirement to obtain my doctor of education (Ed.D.) degree from the University of Tennessee in Knoxville, with a concentration in Instructional Technology and Educational Studies. I have developed an interest in assistive technology during my studies, and have worked with persons with disabilities in my profession as a physical therapist. I am particularly interested in persons with severe neurological conditions.

By employing a review of the current literature in education, neuroscience, and rehabilitation; I have identified areas that may be incorporated into an assessment for computer access utilizing assistive technology. I have listed these in a survey to rate the importance of the various elements to the assessment process. The assessment is a team effort involving the person receiving the device and their family. The assessment process requires input from many professionals and persons close to the individual, and should reflect this in a detailed and comprehensive assessment to gather information to arrive at the right decision. Therefore, the categories that I have listed encompass a broad range of areas that require input from the team, given that nobody can possibly know everything about the emerging discipline of assistive technology. Furthermore, due to the complex nature of persons with severe disabilities, they oftentimes are not provided effective computer access.

I have included a link to an electronic form which utilizes a Delphi format to determine which categories should be used in an assessment for computer access. I have delineated subcategories under each category. There are four ratings under each subcategory: very important, important, somewhat important, or not important, by which you determine the value of each item to the assessment process. You will need to check one of these under each subcategory. There is also a section under each category for any comments you may wish to include. There are two buttons at the end of the form that allow you to clear or send the form. The form has 22 categories (54 subcategories), but should not take more than about 45 minutes or so to complete, including a few comments. I will be sending a second revised form to respondents of the items rated as necessary to the assessment process in the initial survey to gain a further consensus or convergence on what elements should be incorporated in an assessment. This will take place within 3-4 weeks of the first survey.

I have transmitted this form to persons who are credentialed or hold a certificate as an assistive technology practitioner (i.e. CSUN and RESNA), or researchers who have published in the field. This includes persons in the fields of education, speech therapy, occupational therapy, and physical therapy. Please read the directions at the top of the form carefully. To access the form click on the following link:
http://web.utk.edu/~bhoppest/form4.html

Thank you for your time and effort in assisting me with my study. You can visit my homepage by clicking on the link at the bottom of this page if you would like more information about me or regarding the study. If you have any further questions or comments, please e-mail me at bhoppest@utk.edu.

Respectfully,
Brian Hoppestad MS, PT
Doctoral Candidate
University of Tennessee
College of Education, Instructional Technology and Educational Studies

Appendix E- Survey Form for First Iteration

Thank you for participating in my study!

Your comments are greatly appreciated!

Please give your name and e-mail address. Complete this form by checking only one answer under each subcategory. Simply click on the box that you feel rates the importance of each subcategory listed in the survey. You may also offer any comments you feel are necessary by clicking the comment box and typing your comment. After rating each item on the survey press send when ready to submit. If you press clear all of your answers will be erased. If you need to change any of your answers just click again on the box that you have checked to erase the answer. To delete any comments, just click on the comment box and press the delete button on your keyboard. Your answers will be recorded and rated from 1=not important to 4=very important. A thank you page will be sent to you with your answers. Please ignore the ad at the top of the page as I am using a third party site to process the form. However, there is no need to worry, your e-mail address will not be harvested or given away for any unwanted e-mail solicitations. Data will be used for statistical purposes only, and you will remain anonymous. All survey responses will be deleted shortly after completion of the study. There is also a link to my homepage in the thank you letter under "return to homepage" if you wish to go there for more information about the study.

Your name: ____________________

Email address: ____________________

Categories:

After obtaining the general background information including demographics such as the individual's age, race, etc., and making contact with significant others--family members, caregivers, legal guardians or others associated with the individual--from the referral source; what elements are critical to the assessment process?

1) **Prior or Current Use of Assistive Technology**

Prior Utilization-use of assistive technology devices in the past or current use to maintain or improve function. Prior success or the effectiveness of prior assistive technology devices for computer access in the home, school, or other environment. Related services rendered to the person such as physical, occupational, or speech therapy.

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Comments:

2) **Medical Background**

Health Exam-the most recent health exam or physical. List of previous medical diagnoses and treatment for a physical or mental condition. May encompass treatment for conditions such as brain injury (acquired or present at birth), cerebral palsy, Parkinson's disease, cerebrovascular accident, encephalitis, metabolic abnormalities, mental retardation, neurodegenerative disorders, trauma, seizures, or any other pertinent medical condition.

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Comments:

3) **Family Background**

Economic Resources- financial situation of the individual and his or her family or significant others to support the use of assistive technology.

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Support Resources-includes assistance for training to use the device from a professional and/or aid and acceptance from the family. Social support systems denoting the degree of emotional and social support that can be expected for the person with a disabling condition such as help in adapting to change or encouragement when using the device.

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Comments:

4) **Cultural Factors**

Cultural Values-the attitudes and beliefs of the cultural group to which the person belongs and their influence on the individual.

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Comments:

5) **Educational Background**

Formal Education-level of learning or achievement that has been attained by the individual. Current school records and teacher observations.

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Academic Testing-types of academic testing that have been performed to demonstrate academic achievement. This may encompass testing of psychomotor skills, literacy (sounds, words, meaning of text) or other relevant assessments.

- ☐ Very Important
- ☐ Important

☐ Somewhat Important

☐ Not Important

Supportiveness of School Staff-support by the school for assistive technology if used in an educational environment.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Comments:

6) **Goals for Use of Assistive Technology**

Assessment Team Goals-the goals or objectives related to work, school, leisure, or activities of daily living (e.g. environmental control) set by the assessment team. Task assessments for needs in the person's own environment(s).

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Individual/Family Goals-the goals that the individual and/or their family hope to achieve using assistive technology.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Comments:

7) **Communication**

Expressive Communication-individual's ability to express language. How the individual expresses their desires, needs or ideas. Modes of expression such as facial expressions, sign language, gestures, pictures, yes/no responses, pointing, or augmentative communication devices. Most proficient method of expression, either oral or written language.

☐ Very Important
☐ Important
☐ Somewhat Important
☐ Not Important

Language Disorders-diagnoses such as aphasia-receptive or expressive, agraphia-inability to write, alexia-inabity to recognize words, or some other disorder of communication. Results of the most recent speech and language evaluation if available.

☐ Very Important
☐ Important
☐ Somewhat Important
☐ Not Important

Receptive Capabilities-ability to understand and respond to speech and the means by which the person executes a response. The ability to understand directions. Response to symbols, concrete ideas, or abstract ideas (representational thinking). The ability to comprehend what they have read or heard.

☐ Very Important
☐ Important
☐ Somewhat Important
☐ Not Important

Comments:

8) **Cognition**

Cognitive Function-incorporates areas such as executive function, perceptual organization, organizational skills, sequencing, following directions, and problem solving. Measured through observation or testing in areas such as object identification and association, task initiation, ability to learn new tasks, comprehension, and abstract thinking.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Observations of Impairments-diminished responses to sensations, inability to make decisions, a lack of insight, slowed processing of information, limited comprehension of cause and effect, and communication deficits.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Comments:

9) **Behavior**

Affective Characteristics-emotional state of the individual portrayed as the person's attitudes manifested in their personality traits and affective responses. Person may become over-stimulated and cannot control their behavior, or they may be passive and lack motivation to participate in activities.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

General Personality Traits-attributes such as impulsivity, difficulties with anger management, frustration, anxiety, depression, irritability, apathy, fatigue, episodes of uncontrollability, disinhibition, agitation, akathesia (restlessness), or the inability to manage mood state.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Disordered Thought Processes-how behavior or affective characteristics affect learning, organization of thoughts, and level of comprehension.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Comments:

10) **Attention**

Attentiveness-attention evidenced by ability to concentrate, orientation, level of arousal, or reaction to stimuli. Appropriate emotional or physical response to stimuli. Ability to filter out extraneous stimuli. Hyposensitivity or hypersensitivity to stimuli. Divided attention such as attention to multiple tasks concurrently, the ability to complete tasks, and capacity to follow directions (simple or complex).

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Comments:

11) **Intelligence**

Formal Measures-measures of verbal and nonverbal intelligence. Capability to problem-solve and execute abstract thought processes.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Observation of Performance-ability to coordinate different tasks and make determinations or correct judgments in a particular context. Capabilities and interests of the individual can be indicative of intelligence in a certain domain.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Comments:

12) **Memory**

Declarative and Procedural Memory-implicit (procedural) and explicit (declarative). Procedural is automatic tasks that we should be able to recall easily, e.g. how to wash the dishes. Declarative memory requires the individual to outline or narrate something that has happened.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Semantic Memory-level of semantic memory (recall the meaning of some event).

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Comments:

13) **Social Adjustment**

Observational Analysis-include awareness levels, body language, gross vocalizations, toleration of an activity as well as length of participation, interaction with others, and the presence of a social support system. The insight to determine how past experiences or actions can affect present situations, and the consequences.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Basic Social Skills-personality traits. The person may exhibit impaired interpersonal skills, and decreased self-awareness of impaired decisions, with or without the presence of limited memory or language comprehension (perceptual abilities).

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Comments:

14) **Sensory/Perceptual**

Sensory Input-excluding hearing and sight, sensory inputs such as pain, tactile, temperature, vestibular, proprioceptive, kinesthetic, recognition, smell, and taste. This encompasses any part of the body, including the mouth, head, and tongue.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Perceptual Input-impaired perception of sensory input such as visuospatial orientation, constructional abilities-recognition of environment, self-awareness-appropriate emotional responses to stimuli. Perceptual disorders such as: hemineglect-unawareness of one side of the body; agraphia-inability to process information to write; alexia-inability to recognize words; agnosia-inability to recognize objects; astereognosis-inability to determine what an object is by feel; or agnosognosia-lack of insight or denial causing impaired awareness of a disability.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Comments:

15) **Vision**

Visual Acuity-results of most recent visual exam.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Visual Perception-excluding blindness or decreased visual acuity, problems such as: visual field loss; the inability to perceive the entire picture or to integrate its parts; failure to attend to objects presented in a particular location within the visual field; failure to recognize objects with vision alone; double vision (diploplia); inability to distinguish colors; or inability to fixate on an object or track it when it moves. Also, difficulty with visually guided movements, spatial recognition (i.e. depth perception), ocular motor function, gaze shift, scanning, sensitivity (e.g. to light), nystagmus (involuntary eye movements), strabismus (inability to focus using both eyes), and peripheral or central vision loss

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Comments:

16) **Auditory**

Auditory Exam-the most recent auditory exam with the results for hearing loss and functional hearing ability.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Auditory Processing-response to sounds, sensitivity to sound, and ability to distinguish background sounds.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Comments:

17) **Motor control**

Muscle Strength-the capacity to activate muscles, sustain contractions, and maintain proper tone during movement. Atrophy (wasting) or hypertrophy (abnormal increase in size) of the muscles.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Muscle Endurance-the ability to perform movements without undue fatigue of the muscles.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Coordination or Movement Quality-deficits in motor development level, initiating and stopping movements, coordination-force, range, direction, or velocity of the movement, non-fluid or erratic movements, restricted or excessive movements, rhythm, reaction time (e.g. reach and grasp), and motor planning are assessed. Conditions that impair movement such as tremors, quadriplegia, paraplegia, hemiplegia, athetosis (slow writhing motions), choreas (sudden irregular movements), dsytonia (sustained contractions of muscles), hemiballismus (quick forceful involuntary movements), dyssynergia (abnormal movement patterns), dysmetria (inaccuracy in targeting movements), dysdiadochokinesia (impaired alternating movements), ataxia (impaired balance), apraxia (problem sequencing movements), and hypokinesia (slow movements such as bradykinesia and akinesia).

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Muscle Tone-abnormal or altered muscle tone, such as spasticity (velocity dependent increase in tone) or rigidity (non-velocity dependent increase in tone). Involuntary or associated movements that occur in hypertonic muscles when another part of the body is moved.

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Functional Mobility-the person's dependence or independence with daily tasks, bed mobility, transfers, and ambulation, mobility with or without a device including a wheelchair (manual or electric).

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Fine Motor Coordination-functions such as visual motor, tactile and spatial tasks, hand preference, grasp and release, ability to manipulate objects, finger and thumb movement, dexterity, ability to draw, the area the person can accurately point to (size of grid or switch), and isolated movements. Cranial nerve function innervating the muscles controlling swallowing, facial movements, and sensation of face. Dysphagia (difficulty swallowing) or dysarthria (inability to articulate words) due to weakness or dysfunction of the muscle.

- ☐ Very Important
- ☐ Important

☐ Somewhat Important

☐ Not Important

Motor Responses or Initiation-body regions with the most consistent motor response for computer access.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Comments:

18) **Range of Movement**

Range of Motion-ability to move the joints through their full range including the spine. Presence of contractures (permanent shortening of the muscle).

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Comments:

19) **Posture**

Scoliosis or Kyphosis-curvature of the spine in a side to side direction or curvature of the spine forward.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Postural Stability-stability in various postures or equilibrium (unsupported sitting or standing). Also, the ability to maintain or regain upright posture in sitting or standing. Head control and alignment of the spine and extremities in various positions. Trunk control or strength of the trunk muscles. Trunkal ataxia or inability to coordinate muscles to maintain stability or move trunk in a controlled manner.

- [ ] Very Important
- [ ] Important
- [ ] Somewhat Important
- [ ] Not Important

Postural Support-current utilization of postural support such as a custom designed wheelchair or need for a device to support body in various positions.

- [ ] Very Important
- [ ] Important
- [ ] Somewhat Important
- [ ] Not Important

Comments:

20) **Team Approach**

Collaboration-collaborative team approach to the assessment involving the individual being prescribed the device,and their caregivers and family members.

- [ ] Very Important
- [ ] Important
- [ ] Somewhat Important
- [ ] Not Important

Qualified Team Members-the availability of resource personnel or qualified individuals to conduct the assessment process.

- [ ] Very Important
- [ ] Important
- [ ] Somewhat Important
- [ ] Not Important

Comments:

21) **Environment**

Environmental Assessment-evaluation by the team to gain a perspective on where the person will use the technology, and their capacity to manage tasks in various contexts.

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Trials in Environment-trials conducted in natural, customary environments such as the home, school or work. Ecological inventory of barriers to using a device in various environments.

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Comments:

22)**Trials/Devices**

General Computer Competencies-ability to operate a computer such as turning the computer and monitor on/off or inserting a disc.

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Input Devices-components utilized for trials such as a keyboard with accessibility options, word prediction software, key guard, arm support, trackball, joystick, alternative keyboards, switch, scanning, head pointing device, touchscreen or voice recognition.

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Output Devices-devices utilized such as text enlargement, synthesized speech, or Braille.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Device Flexibility-ability to use device permitting easy access to accommodate the individual's needs. Device integrated for use in a variety of environments for different tasks. Not too complex or cumbersome for ordinary everyday use.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Compatibility-devices offered are compatible with other hardware or software.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Technical Support-availability of technical support for devices.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Family or Support Personnel-staff, caregiver, or family responsibilities for trials, equipment set-up and operation, training, data collection, and length of trial.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Affordability-economic considerations when purchasing device.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Comments:

[ ] Send Clear

Appendix F- Sample Letter of Introduction to Panel of Experts for Round Two of the Delphi Study

Dear Study Participants:

The purpose of a Delphi study is to gain a consensus on a complex issue utilizing the experience of experts in the field. This data can be used to make rational or informed determinations regarding a particular subject where little prior data exists. It can also be used to provide information to launch further exploration of the subject through various methods of study.

The first round of the study obtained a fairly strong consensus for the inclusion of many of the areas in an assessment for adaptive computer access. A smaller number of elements were excluded or somewhere in between. There were also numerous comments that were proffered endorsing or opposing a particular area. The feedback was very constructive, and was offered by a diverse population with exceptional credentials and experience in the area of AT.

I have been corresponding with my committee members regarding the results of the initial round of the Delphi study and reviewing the data. I have selected which elements to retain or delete for the second iteration. I have also elected to add a subcategory proposed by one of the study participants.

I calculated the percentages for the responses to each subcategory. I used a benchmark of 80% of the participants responding "very important" or "important" in order to include that particular element in the next round, but I did not adhere solely to this criteria.
I also looked at the overall percentage, distribution of responses, the comments by the respondents, and information from the literature.

The quality of the study depends on your knowledge and background. You will be reviewing exact duplicates of subcategories retained from the first survey, plus one new one. This makes a total of 46, compared with 54 on the initial iteration. I know you have seen these subcategories previously. You should contemplate again how you may want to respond based on your knowledge, experience, and the data that has been presented. Additionally, any comments are regarded as an asset to the study. Hopefully, this round will produce a greater consensus on the elements.

Just follow the directions at the beginning of the survey. If you could complete the survey in the next two weeks—on or before February 26—it would be very helpful. Feel free to contact me with any questions.

Here is the link to the survey form for the second round:
http://web.utk.edu/~bhoppest/form5.html

Thank you all for your time and effort in assisting me with the study. I sincerely hope it will contribute in some manner to the field of AT.

Respectfully,

Brian Hoppestad MS, PT
Doctoral Candidate
University of Tennessee
College of Education, Instructional Technology and Educational Studies

Appendix G- Survey Form for Second Iteration

Delphi Study for Computer Access: Round Two

Thank you for participating in my study!

Please give your name and e-mail address. Complete this form by checking only one answer under each subcategory. Simply click on the box that you feel rates the importance of each subcategory listed in the survey. You may also offer any comments you feel are necessary by clicking the comment box and typing your comment. After rating each item on the survey press send when ready to submit. If you press clear all of your answers will be erased. If you need to change any of your answers just click again on the box that you have checked to erase the answer. To delete any comments, just click on the comment box and press the delete button on your keyboard. Your answers will be recorded and rated from 1=not important to 4=very important. A thank you page will be sent to you with your answers. Please ignore the ad at the top of the page as I am using a third party site to process the form. However, there is no need to worry, your e-mail address will not be harvested or given away for any unwanted e-mail solicitations. Data will be used for statistical purposes only, and you will remain anonymous. All survey responses will be deleted shortly after completion of the study. There is also a link to my homepage in the thank you letter under "return to homepage" if you wish to go there for more information about the study.

Your name:

Email address:

Categories:

After obtaining the general background information including demographics such as the individual's age, race, etc., and making contact with significant others--family members, caregivers, legal guardians or others associated with the individual--from the referral source; what elements are critical to the assessment process?

1) **Prior or Current Use of Assistive Technology**
Prior Utilization-use of assistive technology devices in the past or current use to maintain or improve function. Prior success or the effectiveness of prior assistive technology devices for computer access

in the home, school, or other environment. Related services rendered to the person such as physical, occupational, or speech therapy.

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Comments:

2) **Medical Background**

Health Exam-the most recent health exam or physical. List of previous medical diagnoses and treatment for a physical or mental condition. May encompass treatment for conditions such as brain injury (acquired or present at birth), cerebral palsy, Parkinson's disease, cerebrovascular accident, encephalitis, metabolic abnormalities, mental retardation, neurodegenerative disorders, trauma, seizures, or any other pertinent medical condition.

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Comments:

3) **Family Background**

Support Resources-includes assistance for training to use the device from a professional and/or aid and acceptance from the family. Social support systems denoting the degree of emotional and social support that can be expected for the person with a disabling condition such as help in adapting to change or encouragement when using the device.

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Comments:

4) **Cultural Factors**

Cultural Values-the attitudes and beliefs of the cultural group to which the person belongs and their influence on the individual.

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Comments:

5) **Educational Background**

Supportiveness of School Staff-support by the school for assistive technology if used in an educational environment.

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Comments:

6) **Goals for Use of Assistive Technology**

Assessment Team Goals-the goals or objectives related to work, school, leisure, or activities of daily living (e.g. environmental control) set by the assessment team. Task assessments for needs in the person's own environment(s).

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Individual/Family Goals-the goals that the individual and/or their family hope to achieve using assistive technology.

- [ ] Very Important
- [ ] Important
- [ ] Somewhat Important
- [ ] Not Important

Comments:

7) **Communication**

Expressive Communication-individual's ability to express language. How the individual expresses their desires, needs or ideas. Modes of expression such as facial expressions, sign language, gestures, pictures, yes/no responses, pointing, or augmentative communication devices. Most proficient method of expression, either oral or written language.

- [ ] Very Important
- [ ] Important
- [ ] Somewhat Important
- [ ] Not Important

Language Disorders-diagnoses such as aphasia-receptive or expressive, agraphia-inability to write, alexia-inabity to recognize words, or some other disorder of communication. Results of the most recent speech and language evaluation if available.

- [ ] Very Important
- [ ] Important
- [ ] Somewhat Important
- [ ] Not Important

Receptive Capabilities-ability to understand and respond to speech and the means by which the person executes a response. The ability to understand directions. Response to symbols, concrete ideas, or abstract ideas (representational thinking). The ability to comprehend what they have read or heard.

- [ ] Very Important
- [ ] Important

☐ Somewhat Important

☐ Not Important

Comments:

8) **Cognition**

Cognitive Function-incorporates areas such as executive function, perceptual organization, organizational skills, sequencing, following directions, and problem solving. Measured through observation or testing in areas such as object identification and association, task initiation, ability to learn new tasks, comprehension, and abstract thinking.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Observations of Impairments-diminished responses to sensations, inability to make decisions, a lack of insight, slowed processing of information, limited comprehension of cause and effect, and communication deficits.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Comments:

9) **Behavior**

Affective Characteristics-emotional state of the individual portrayed as the person's attitudes manifested in their personality traits and affective responses. Person may become over-stimulated and cannot control their behavior, or they may be passive and lack motivation to participate in activities.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

General Personality Traits-attributes such as impulsivity, difficulties with anger management, frustration, anxiety, depression, irritability, apathy, fatigue, episodes of uncontrollability, disinhibition, agitation, akathesia (restlessness), or the inability to manage mood state.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Disordered Thought Processes-how behavior or affective characteristics affect learning, organization of thoughts, and level of comprehension.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Comments:

10) **Attention**

Attentiveness-attention evidenced by ability to concentrate, orientation, level of arousal, or reaction to stimuli. Appropriate emotional or physical response to stimuli. Ability to filter out extraneous stimuli. Hyposensitivity or hypersensitivity to stimuli. Divided attention such as attention to multiple tasks concurrently, the ability to complete tasks, and capacity to follow directions (simple or complex).

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Comments:

11) **Intelligence**

Observation of Performance-ability to coordinate different tasks and make determinations or correct judgments in a particular context. Capabilities and interests of the individual can be indicative of intelligence in a certain domain.

- [ ] Very Important
- [ ] Important
- [ ] Somewhat Important
- [ ] Not Important

Comments:

12) **Memory**

Declarative and Procedural Memory-implicit (procedural) and explicit (declarative). Procedural is automatic tasks that we should be able to recall easily, e.g. how to wash the dishes. Declarative memory requires the individual to outline or narrate something that has happened.

- [ ] Very Important
- [ ] Important
- [ ] Somewhat Important
- [ ] Not Important

Semantic Memory-level of semantic memory (recall the meaning of some event).

- [ ] Very Important
- [ ] Important
- [ ] Somewhat Important
- [ ] Not Important

Comments:

13) **Social Adjustment**
Observational Analysis-include awareness levels, body language, gross vocalizations, toleration of an activity as well as length of participation, interaction with others, and the presence of a social support system. The insight to determine how past experiences or actions can affect present situations, and the consequences.

- [ ] Very Important
- [ ] Important
- [ ] Somewhat Important
- [ ] Not Important

Comments:

14) **Sensory/Perceptual**
Sensory Input-excluding hearing and sight, sensory inputs such as pain, tactile, temperature, vestibular, proprioceptive, kinesthetic, recognition, smell, and taste. This encompasses any part of the body, including the mouth, head, and tongue.

- [ ] Very Important
- [ ] Important
- [ ] Somewhat Important
- [ ] Not Important

Perceptual Input-impaired perception of sensory input such as visuospatial orientation, constructional abilities-recognition of environment, self-awareness-appropriate emotional responses to stimuli. Perceptual disorders such as: hemineglect-unawareness of one side of the body; agraphia-inability to process information to write; alexia-inability to recognize words; agnosia-inability to recognize objects; astereognosis-inability to determine what an object is by feel; or agnosognosia-lack of insight or denial causing impaired awareness of a disability.

- [ ] Very Important
- [ ] Important
- [ ] Somewhat Important
- [ ] Not Important

Comments:

15) **Vision**
Visual Acuity-results of most recent visual exam.

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Visual Perception-excluding blindness or decreased visual acuity, problems such as: visual field loss; the inability to perceive the entire picture or to integrate its parts; failure to attend to objects presented in a particular location within the visual field; failure to recognize objects with vision alone; double vision (diploplia); inability to distinguish colors; or inability to fixate on an object or track it when it moves. Also, difficulty with visually guided movements, spatial recognition (i.e. depth perception), ocular motor function, gaze shift, scanning, sensitivity (e.g. to light), nystagmus (involuntary eye movements), strabismus (inability to focus using both eyes), and peripheral or central vision loss

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Comments:

16) **Auditory**
Auditory Exam-the most recent auditory exam with the results for hearing loss and functional hearing ability.

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Auditory Processing-response to sounds, sensitivity to sound, and ability to distinguish background sounds.

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Comments:

17) **Motor control**

Muscle Strength-the capacity to activate muscles, sustain contractions, and maintain proper tone during movement. Atrophy (wasting) or hypertrophy (abnormal increase in size) of the muscles.

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Muscle Endurance-the ability to perform movements without undue fatigue of the muscles.

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Coordination or Movement Quality-deficits in motor development level, initiating and stopping movements, coordination-force, range, direction, or velocity of the movement, non-fluid or erratic movements, restricted or excessive movements, rhythm, reaction time (e.g. reach and grasp), and motor planning are assessed. Conditions that impair movement such as tremors, quadriplegia, paraplegia, hemiplegia, athetosis (slow writhing motions), choreas (sudden irregular movements), dsytonia (sustained contractions of muscles), hemiballismus (quick forceful involuntary movements), dyssynergia (abnormal movement patterns), dysmetria (inaccuracy in targeting movements), dysdiadochokinesia (impaired alternating movements), ataxia (impaired balance), apraxia (problem sequencing movements), and hypokinesia (slow movements such as bradykinesia and akinesia).

- [ ] Very Important
- [ ] Important
- [ ] Somewhat Important
- [ ] Not Important

Muscle Tone-abnormal or altered muscle tone, such as spasticity (velocity dependent increase in tone) or rigidity (non-velocity dependent increase in tone). Involuntary or associated movements that occur in hypertonic muscles when another part of the body is moved.

- [ ] Very Important
- [ ] Important
- [ ] Somewhat Important
- [ ] Not Important

Functional Mobility-the person's dependence or independence with daily tasks, bed mobility, transfers, and ambulation, mobility with or without a device including a wheelchair (manual or electric).

- [ ] Very Important
- [ ] Important
- [ ] Somewhat Important
- [ ] Not Important

Fine Motor Coordination-functions such as visual motor, tactile and spatial tasks, hand preference, grasp and release, ability to manipulate objects, finger and thumb movement, dexterity, ability to draw, the area the person can accurately point to (size of grid or switch), and isolated movements. Cranial nerve function innervating the muscles controlling swallowing, facial movements, and sensation of face. Dysphagia (difficulty swallowing) or dysarthria (inability to articulate words) due to weakness or dysfunction of the muscle.

- [ ] Very Important
- [ ] Important
- [ ] Somewhat Important

☐ Not Important

Motor Responses or Initiation-body regions with the most consistent motor response for computer access.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Comments:

18) **Range of Movement**

Range of Motion-ability to move the joints through their full range including the spine. Presence of contractures (permanent shortening of the muscle).

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Comments:

19) **Posture**

Scoliosis or Kyphosis-curvature of the spine in a side to side direction or curvature of the spine forward.

☐ Very Important

☐ Important

☐ Somewhat Important

☐ Not Important

Postural Stability-stability in various postures or equilibrium (unsupported sitting or standing). Also, the ability to maintain or regain upright posture in sitting or standing. Head control and alignment of the spine and extremities in various positions. Trunk control or strength of the trunk muscles. Trunkal ataxia or inability to coordinate muscles to maintain stability or move trunk in a controlled manner.

- [ ] Very Important
- [ ] Important
- [ ] Somewhat Important
- [ ] Not Important

Postural Support-current utilization of postural support such as a custom designed wheelchair or need for a device to support body in various positions.

- [ ] Very Important
- [ ] Important
- [ ] Somewhat Important
- [ ] Not Important

Comments:

20) **Team Approach**

Collaboration-collaborative team approach to the assessment involving the individual being prescribed the device,and their caregivers and family members.

- [ ] Very Important
- [ ] Important
- [ ] Somewhat Important
- [ ] Not Important

Qualified Team Members-the availability of resource personnel or qualified individuals to conduct the assessment process.

- [ ] Very Important
- [ ] Important
- [ ] Somewhat Important
- [ ] Not Important

Comments:

21) **Environment**

Environmental Assessment-evaluation by the team to gain a perspective on where the person will use the technology, and their capacity to manage tasks in various contexts.

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Trials in Environment-trials conducted in natural, customary environments such as the home, school or work. Ecological inventory of barriers to using a device in various environments.

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Comments:

22)**Trials / Devices**

Device Flexibility-ability to use device permitting easy access to accommodate the individual’s needs. Device integrated for use in a variety of environments for different tasks. Not too complex or cumbersome for ordinary everyday use.

- ☐ Very Important
- ☐ Important
- ☐ Somewhat Important
- ☐ Not Important

Compatibility-devices offered are compatible with other hardware or software.

- ☐ Very Important

☐ Important
☐ Somewhat Important
☐ Not Important

Technical Support-availability of technical support for devices.
☐ Very Important
☐ Important
☐ Somewhat Important
☐ Not Important

Family or Support Personnel-staff, caregiver, or family responsibilities for trials, equipment set-up and operation, training, data collection, and length of trial.
☐ Very Important
☐ Important
☐ Somewhat Important
☐ Not Important

Follow-up-needs to be included in the report area. Short term ...training/follow-up, long term follow-up to review the the user's needs (look at changes,etc.)and update etc. **(participant added)**
☐ Very Important
☐ Important
☐ Somewhat Important
☐ Not Important

Comments:

Send Clear

Appendix H- Results from First Survey

Table H-1: Responses to Delphi Study (First Round)

Category	Subcategory	Very Important	Important	Somewhat Important	Not Important	% Very Important/ Important
1) **Prior or Current Use of Assistive Technology**	*Prior Utilization*	22	7	4		89
2) **Medical Background**	*Health Exam*	14	14	5		85
3) **Family Background**	*Economic Resources*	6	13	12	1	59
	Support Resources	26	6	1		97
4) **Cultural Factors**	*Cultural Values*	14	10	8		75
5) **Educational Background**	*Formal Education*	10	14	7	2	73
	Academic Testing	9	14	10		70
	Supportiveness of School Staff	23	9	1		97
6) **Goals for Use of Assistive Technology**	*Assessment Team Goals*	25	8			100
	Individual/Family Goals	25	6	2		94
7)**Communication**	*Expressive Communication*	23	9	1		97
	Language Disorders	21	10	2		94
	Receptive Capabilities	27	5	1		97
8) **Cognition**	*Cognitive Function*	22	10	1		97
	Observations of Impairments	20	13			100
9) **Behavior**	*Affective Characteristics*	15	16	2		94
	General Personality Traits	14	15	4		89
	Disordered Thought Processes	17	14	2		94

Table H-1 Continued

Category	Subcategory	Very Important	Important	Somewhat Important	Not Important	% Very Important/ Important
10) **Attention**	*Attentiveness*	19	13	1		97
11) **Intelligence**	*Formal Measures*	6	17	9	1	70
	Observation of Performance	14	16	2		97
12) **Memory**	*Declarative and Procedural Memory*	13	16	4		89
	Semantic Memory	9	16	8		76
13) **Social Adjustment**	*Observational Analysis*	9	17	7		74
	Basic Social Skills	6	16	11		67
14)**Sensory/ Perceptual**	*Sensory Input*	17	14	2		94
	Perceptual Input	22	10	1		97
15) **Vision**	*Visual Acuity*	18	13	2		94
	Visual Perception	21	9	2		94
16) **Auditory**	*Auditory Exam*	15	15	3		91
	Auditory Processing	18	12	3		91
17) **Motor control**	*Muscle Strength*	19	11	3		91
	Muscle Endurance	19	12	2		94
	Coordination or Movement Quality	19	13	1		97
	Muscle Tone	19	13	1		97
	Functional Mobility	15	13	3		90
	Fine Motor Coordination	26	6	1		97
	Motor Responses or Initiation	21	11			100
18) **Range of Movement**	*Range of Motion*	14	15	4		89

Table H-1 Continued

Category	Subcategory	Very Important	Important	Somewhat Important	Not Important	% Very Important/ Important
19) **Posture**	*Scoliosis or Kyphosis*	11	16	5		84
	Postural Stability	18	13	2		94
	Postural Support	17	13	3		91
20) **Team Approach**	*Collaboration*	25	8			100
	Qualified Team Members	28	5			100
21) **Environment**	*Environmental Assessment*	30	2	1		97
	Trials in Environment	25	7	1		97
22)**Trials/Devices**	*General Computer Competencies*	13	10	9	1	70
	Input Devices	24	8			100
	Output Devices	23	9	1		97
	Device Flexibility	24	7	1		97
	Compatibility	22	9	2		94
	Technical Support	25	7	1		97
	Family or Support Personnel	25	7		1	97
	Affordability	11	12	9		70

Appendix I- Results from Second Survey Round

Table I-1: Responses to Delphi Study (Second Round)

Category	Subcategory	Very Important	Important	Somewhat Important	Not Important	% Very Important/ Important
1) **Prior or Current Use of Assistive Technology**	*Prior Utilization*	15	9	1	1	92
2) **Medical Background**	*Health Exam*	9	13	4		85
3) **Family Background**	*Support Resources*	15	11	1		96
4) **Cultural Factors**	*Cultural Values*	7	13	5	2	74
5) **Educational Background**	*Supportiveness of School Staff*	18	7	2		93
6) **Goals for Use of Assistive Technology**	*Assessment Team Goals*	20	6	0		100
	Individual/Family Goals	19	5	2		92
7) **Communication**	*Expressive Communication*	16	5	6		78
	Language Disorders	12	11	3		88
	Receptive Capabilities	14	9	4		85
8) **Cognition**	*Cognitive Function*	15	9	3		89
	Observations of Impairments	17	7	3		89
9) **Behavior**	*Affective Characteristics* Subcategory	11	12	3		88
	General Personality Traits	9	14	4		85
	Disordered Thought Processes	10	15	1		96
10) **Attention**	*Attentiveness*	9	17	1		96
11) **Intelligence**	*Observation of Performance*	8	15	3	1	85
12) **Memory**	*Declarative and Procedural Memory*	10	12	5		81

Table I-1: Continued

Category	Subcategory	Very Important	Important	Somewhat Important	Not Important	% Very Important/ Important
Memory (Cont.)	*Semantic Memory*	7	12	7	1	70
13) **Social Adjustment**	*Observational Analysis*	5	13	8	1	67
14)**Sensory/Perceptual**	*Sensory Input*	14	7	6		78
	Perceptual Input	14	9	4		85
15) **Vision**	*Visual Acuity*	14	8	5		81
	Visual Perception	17	8	2		93
16) **Auditory**	*Auditory Exam*	13	7	7		74
	Auditory Processing	12	11	4		85
17)**Motor**	*Muscle Strength*	18	6	3		89
	Muscle Endurance	17	7	2	1	89
	Coordination or Movement Quality	18	8	1		96
	Muscle Tone	17	7	3		89
	Functional Mobility	14	9	2	1	85
	Fine Motor Coordination	20	6	1		96
	Motor Responses or Initiation	20	5	1		96
18) **Range of Movement**	*Range of Motion*	14	9	3	1	85
19) **Posture**	*Scoliosis or Kyphosis*	10	11	5	1	78
	Postural Stability	11	14	2		93
	Postural Support	11	11	3	1	85
20) **Team Approach**	*Collaboration*	23	2	1		96
	Qualified Team Members	23	4			100

Table I-1: Continued

Category	Subcategory	Very Important	Important	Somewhat Important	Not Important	% Very Important/ Important
21) **Environment**	*Environmental Assessment*	19	8			100
	Trials in Environment	18	9			100
22) **Trials/Devices**	*Device Flexibility*	19	6	1		96
	Compatibility	19	7	1		96
	Technical Support	19	7	1		96
	Family or Support Personnel	20	5			100
	Follow-up	22	5			100

Appendix J-Permission for Use of Figures

HEALTH PROFESSIONS/MEDICINE

PERMISSONS

TO: Brian Hoppestad, bhoppest@utk.edu
FROM: Kimberly L. Harris
RE: **Fredericks/Saladin, (0-8036-0093-3)** and **Gilman/Newman, (0-8036-0772-5)**
DATE: April 4, 2004

Permission is granted to Brian Hoppestad to reprint the material referenced below, on a one-time use basis, in English only, for North American distribution only, and in print only (no electronic rights are granted). The material will be reprinted in his dissertation, "Essential Elements for Assessment of Persons with Severe Neurological Impairments for Computer Access Utilizing Assistive Technology Devices: A Delphi Study."

Book:	*Pathophysiology of the Motor Systems* *Essentials of Clinical Neuroanatomy and Neurophysiology*, 10 edition
Author(s):	Fredericks, Christopher M. and Saladin, Lisa K. Gilman, Sid and Newman, Sarah Winans
Copyright:	1996 2003
Pages:	Fredericks/Saladin: Page 19 - Figure 1.14, Page 79 – Figure 4.2; Page 166 – Figure 7.7; Page 260 – Table 12.1; and Page 278 – Table 12.7 Gilman/Newman: Page 183 – Figure 20.7 (Fredericks/Saladin Figure 7.5)
Description:	For dissertation work for Doctor of Education degree.

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Brian Hoppestad was born in Covington, Virginia on May 23, 1964. He grew up in Louisville, Ky. where he received his primary and secondary school education, graduating from Eastern High School in 1982. He attended the University of Kentucky and received his BS in Physical Therapy in 1987. He also obtained an MS in Exercise Physiology from the University of Tennessee in 1999. He currently is pursuing an Ed.D. degree with a concentration in Instructional Technology and Educational Studies from the University of Tennessee.

Brian has practiced as a clinician in the field of Physical Therapy in numerous settings. Beginning as a staff therapist in Fort Thomas, Ky., he soon became a Director of Rehabilitation for clinics in Kentucky and elsewhere. He has also worked in Florida and Tennessee and has developed an interest in rehabilitation of neurological patients. He has attended numerous continuing education courses and is certified in the Neuro-Dynamic Therapy Approach. He is a longtime member of the American Physical Therapy Association (APTA) and belongs to the Neurology Section.

Brian currently works for National HealthCare as a Staff Physical Therapist. He has won many awards for his leadership of the Rehabilitation Department in the East Tennessee region and nationally during his employment with NHC. He has also lectured for the company on various topics at regional and national meetings related to the field of rehabilitation. He is interested in entering into a new facet of rehabilitation as an Assistive Technology Specialist after obtaining his doctorate.