Reflecting the state of the art in the field, this volume presents the most advanced practices and techniques in the rehabilitation of neuropsychological deficits, covering both specific neuropsychological domains and approaches in neurorehabilitation. Featuring contributions from leading scholars and clinicians in neuropsychology and rehabilitation psychology, this book is guided by the philosophy that it is not enough to identify a deficit or diagnose a disease unless it helps direct rehabilitation efforts to improve functioning. Intended to advance clinical skills, the book goes beyond surface diagnostic practice to foster rehabilitative efforts in response to residual deficits and disease.

The volume begins by addressing the foundations of neuropsychology in rehabilitation and discussing, in depth, domain-specific rehabilitation practices, with a focus on functioning. This coverage is followed by a discussion of supplemental applications and practices that go beyond function-specific methodology, including neuroimaging and pharmacological agents. Also covered is the role of system/environmental manipulation and transitioning strategies, as well as crucial and emerging practice issues such as cross-specialty collaboration and telerehabilitation. Neuropsychologists, clinical psychologists, neurologists, and rehabilitation professionals will find this volume an indispensable resource.

**Key Features:**

- Presents, in depth, the most advanced clinical applications for neuropsychological rehabilitation
- Covers neuropsychological rehabilitation in terms of specific cognitive domains, including attention, language, and memory; as well as practices in neurorehabilitation, including neuroimaging and occupational and pharmacological approaches
- Includes contributions from the foremost scholars and practitioners in the field
Neuropsychological Rehabilitation
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To my wife and children for supporting me through yet another book. Your constant love and encouragement always sees me through—CAN

To my children with all my heart—RSD

To my wife, Mary, and my sons Brian and Zachary for their inspiration to try harder and reach higher—MTB
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Preface

Over the past three decades, medical advances have led to a substantial increase in the number of individuals surviving life-threatening incidents, including neurological trauma. This has led to a sizeable inflation of the number of individuals with significant and prolonged cognitive impairments in memory, reasoning, attention, judgment and self-awareness that negatively impacts their functionality and, in turn, quality of life. The Centers for Disease Control and Prevention estimates that over 5 million Americans are living with disabilities resulting from acquired brain injuries. Neurocognitive impairments are particularly troubling to individuals as they can greatly affect adaptability and are not as easily recognized by the general public. As the brain injury population grew over the past few decades, it became readily apparent that the traditional medical rehabilitation model was insufficient to address these particular functional impairments. Neuropsychology has become particularly important in rectifying these shortcomings.

In modern-day cognitive rehabilitation, neuropsychology is one of many specialties charged with the responsibility of returning individuals with brain injuries to the highest level of functionality and independence possible. While some professionals in neuropsychology still perceive their role as solely focused on assessment and diagnosis, cognitive rehabilitation has become an established practice within the field of neuropsychology. Neuropsychologists are regularly included as part of multidisciplinary rehabilitation teams alongside rehabilitation psychologists, neurologists, cognitive psychologists, speech pathologists, occupational therapists, special education professionals, and physical medicine practitioners. Considering the trends of the last two decades, one may reasonably expect an even greater increase in the reliance on neuropsychology as a core practice in cognitive rehabilitation efforts moving forward. Consequently, professional neuropsychologists as well as those in training must remain up-to-date with the changing landscape that is the practice and science of cognitive rehabilitation. Research continues to shape our models of intervention and rehabilitative techniques. While variability can be seen across the literature regarding the utility and efficacy of cognitive rehabilitative efforts based on their design, measurement, and outcome, the vast majority of studies, including meta-analyses, support such rehabilitative efforts.

Recognizing the advances in the science and practice of cognitive rehabilitation, Neuropsychological Rehabilitation was conceived, with the goal of being a text that discusses these advances from a neuropsychological perspective. This text covers the most advanced practices and techniques in the rehabilitation of neuropsychological deficits, covering both specific neuropsychological domains and approaches in neurorehabilitation. It adheres to the philosophy that it is not enough to identify a deficit or diagnose a disease unless doing so
helps to direct rehabilitation efforts to improve function. Intended to advance clinical skills of professionals and trainees alike, the book goes beyond surface diagnostic practice to foster rehabilitative efforts in response to residual deficits and disease.

This text discusses the foundations of neuropsychology in rehabilitation and along with, in depth, domain-specific rehabilitation practices, with a focus on functioning. Supplemental applications and practices that go beyond function-specific methodology, including neuroimaging and pharmacological agents, are also covered. Similarly, chapters are dedicated to the discussion of the role of system/environmental manipulation and transitioning strategies in rehabilitation. Finally, presentations/groupings most commonly seen in rehabilitation practice for which there is no prototypical form are covered from the standpoint of an integrated, neuropsychological approach.
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A book such as this is only made possible through the contribution of various authors. We want to acknowledge their willingness to volunteer their time and knowledge to this work. As always, we want to acknowledge the support of our colleagues and associated institutions; SIU School of Medicine, Ball State University, and Baylor Institute for Rehabilitation, without whom this project would not be possible. Finally, we would like to express our sincerest gratitude to our publisher and those with whom we have worked very closely to complete this book, especially Nancy S. Hale and Joseph Stubenrauch.
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The Neuropsychology of Psychopathology
The Neuropsychology of Cancer and Oncology
Neuropsychological Rehabilitation
The Neuropsychology of Cortical Dementias
The Neuropsychology of Pervasive Developmental Disorders
The Neuropsychology of Psychopharmacology
Historical Principles and Foundations of Neuropsychological Rehabilitation

Karen K. Brewer-Mixon and C. Munro Cullum

BRIEF HISTORY OF NEUROPSYCHOLOGICAL REHABILITATION

Modern day cognitive rehabilitation (CR) spans a number of disciplines, including speech pathology, occupational therapy, special education, physical medicine, neurology, cognitive psychology, cognitive neuroscience, rehabilitation psychology, and neuropsychology. Rehabilitation has developed as a result of the contributions of all these professions and incorporates many different theories and techniques. Throughout the history of CR, neuropsychology has played a particularly important role.

The earliest rehabilitation efforts may be traced back to the crude efforts of ancient man, who practiced trepanation on persons with damaged skulls and disordered behavior. Later, ancient Greek and Roman scientists endeavored to understand the brain and restoration of function. Although some of their observations were quite sophisticated, such as Hippocrates’ recognition that paralysis occurred opposite the side of a brain injury, they were often misled by the popular religious or cultural beliefs of their time. For example, Aristotle believed mental functions were localized in the heart, and Galen’s “ventricular localization hypothesis” posited that “psychic gases and humours” flowed through the body and ventricles, giving rise to mental functions.

In the 16th century, Vesalius gave us the first scientific neuroanatomical documentation; Descartes’ theories on mind–body dualism and the nature of the mind became dominant in the early 17th century. In 1664, Thomas Willis published Cerebri anatome, the first medical text to describe and depict in drawings the anatomy of the brain and cranial nerves. Three years later, Willis published a complementary text on brain pathology and physiology. More than a century after Willis’ painstaking work in neurology was published, Franz Gall put forth his theory of phrenology. Although Gall’s theory was almost completely incorrect, it was perhaps a springboard for those who would later accurately describe localization of brain function.

In the mid-1800s, Paul Broca, the French physician, anatomist, and anthropologist, began his work. Among his many contributions, he described an intuitive rehabilitation program to restore lost skills in an adult patient who became unable to read aloud (Berker, Berker, & Smith, 1986). Building on Broca’s work, the great German neuropsychiatrist Carl Wernicke was one of the first to conceptualize brain function as a series of regions that were dependent on interconnected neural pathways. This localization and interconnection concept became a fundamental element of clinical neuropsychology and CR.
As the 20th century dawned, prominent American neuropsychologist Shepherd Franz was using scientific methodology to study motor learning in hemiparesis and the effectiveness of therapy in clients with aphasia, making him a pioneer in neuropsychological rehabilitation (Boake, 2003). Like Broca, Franz noticed that his aphasic patients appeared to look more like they were learning a new skill rather than relearning an old habit. This observation established a precedent for using techniques that focus on learning new skills to compensate for abilities lost or diminished due to brain damage (Witsken, D’Amato, & Hartlage, 2008).

During and after the two World Wars, neuropsychology continued to grow as a discipline and to make important contributions to the development of CR. Germany and Austria led the way in developing brain injury rehabilitation centers to treat wounded soldiers. The well-known German psychologist Kurt Goldstein documented his treatment recommendations for speech, reading, and writing impairments. In doing so, he provided a template for rehabilitation efforts that drew on preserved abilities to help brain injury survivors compensate for impaired skills. In addition, his work helped develop behavioral methods for shaping desired behaviors (Witsken et al., 2008). About this same time, the great Soviet neuropsychologist Alexander Luria was working on theories of functional brain systems, based on his work with brain-injured veterans. He would go on to develop rehabilitation methods for working with patients with a variety of cognitive deficits, including aphasia, motor planning, visual perception, and executive functioning disorders (Christensen & Castano, 1996). In 1947, the influential British neuropsychologist Oliver Zangwill made a significant contribution to the field of rehabilitation by delineating three principles/tasks of rehabilitation following brain injury (Zangwill, 1947): (a) substitution, which involves efforts to train brain-injured patients to use alternate strategies in place of those affected by impaired functions; (b) compensation, which relies on the use of alternative strategies to solve problems caused by impaired functioning; and (c) direct training (also called restoration), which involves retraining of impaired areas (Johnstone & Stonnington, 2009).

Cognitive rehabilitation continued to develop through the 20th century using a variety of strategies and techniques. The work of Yehuda Ben-Yishay during the late 1970s and 1980s increasingly recognized the importance of systematically addressing the interpersonal and social needs of clients in order for them to successfully re-enter their social environment. Muriel Lezak (1986) also contributed to the development of rehabilitation with her work on the emotional needs and responses of brain-injured patients and their families. Cicerone went on to explore the relationship between emotional and cognitive dysfunction (Cicerone & Fraser, 2000; Cicerone & Kalmar, 1997) and the understanding and treatment of frontal lobe dysfunction (Cicerone, 2002; Cicerone, Lazar, & Shapiro, 1983). Other ground-breaking work in the understanding, treatment, and management of attentional deficits was provided by Sohlberg and Mateer (1989, 2001); the influential work of Prigatano on awareness in brain-injured patients (Prigatano, 2005) and principles of rehabilitation also advanced the field (Prigatano, 2000).

In the past 50 years, not only has the field of CR made significant strides in its development, but the number of rehabilitation facilities has also grown. Neuropsychological rehabilitation centers in the United States proliferated in the 1980s and 1990s (Parente & Stapleton, 1997), which coincided with the development of advanced medical technologies that increased survival rates for persons with brain injuries. As more and more patients survive, the demand for rehabilitation has increased. During a 5-year period in the 1980s, rehabilitation beds in acute care hospitals increased 46%, and traumatic brain injury (TBI) rehabilitation was reported to be the fastest growing area in all of health care at that time (Frank, Gluck, & Buckelew, 1990).

**NEUROPSYCHOLOGICAL REHABILITATION—TODAY**

Cognitive rehabilitation has become an established practice within the field of neuropsychology. Research supporting the utility and efficacy of these techniques varies widely in terms of designs, measures, and outcomes; however, this contributes to a lack of consensus in the field and skepticism of some regarding the utility of CR procedures for their patients with brain injuries. A number of individual studies and meta-analyses have lent support to CR as
a useful treatment (Bowen & Lincoln, 2007; Robey, 1998), although several Cochrane Reviews have noted “limited evidence” for the effectiveness of CR for deficits in attention, memory, and language following stroke (Greener, Enderby, & Whurr, 1999; Lincoln, Majid, & Weyman, 2000; Majid, Lincoln, & Weyman, 2000; Turner-Stokes, Disler, Nair, & Wade, 2005). Several leaders in the field (Cicerone, 2008) have noted an array of challenging methodological confounds and limitations that exist in most of the studies involving CR to date. Such limitations include heterogeneity of patients (in terms of disorder, duration/level of recovery, level of cognitive disability, age, etc.), as well as limitations and heterogeneity of measurement and intervention techniques (e.g., lack of appropriate control groups, failure to account for spontaneous recovery, and comorbid conditions). As was the case with the early psychotherapy literature, the efficacy of CR is well known to many patients, families, and practitioners, although the class I, evidence-based support for many specific procedures in this area remains in need of further systematic exploration.

Despite mounting evidence of effectiveness (see reviews by Carney et al., 1999; Cicerone, 2008), surprisingly little consensus has yet developed among neuropsychologists and other professionals regarding the best ways in which to remediate cognitive deficits. For example, even though CR programs may be touted as highly effective by patients and families and show improved patient outcomes overall (Rohling, Faust, Beverly, & Demakis, 2009), little is known about the efficacy of specific procedures; it was recently noted that “it is apparent that there is no uniformity of neuropsychological rehabilitation methods offered today, and there is uncertainty about the efficacy of most neuropsychological rehabilitation interventions” (Johnstone & Stonnington, 2009). Still, reports are emerging that compare various neuropsychological rehabilitation approaches. For example, Vanderploeg et al. (2008) reported similar global functional improvements in military personnel and veterans a year after they received either a cognitive–didactic treatment approach or a functional–experiential approach, although participants in the cognitive–didactic arm of the study reported fewer memory problems than those who received the functional–experiential treatment. Interesting influences of age and education also appeared to differentially affect their study participants’ ultimate return-to-work and independent living outcomes. Clearly, there is still a great deal of work yet to be done in developing a more sophisticated understanding as to which CR approaches work best and for which populations.

Current Rehabilitation Models

One of the difficulties in reaching a consensus about how best to remediate cognitive dysfunction has been the dearth of published theoretical rehabilitation models from which methods can be derived. In one of the early attempts at developing a systematic CR program, Reitan and Wolfson (1988) described the Reitan Evaluation of Hemispheric Abilities and Brain Improvement Training (REHABIT). In this approach, a patient’s treatment depended on the patient’s specific neuropsychological deficits. The model was comprised of three levels of information processing: (a) attention, concentration, and memory; (b) lateralized processes (i.e., verbal vs. visuospatial); and (c) higher order abilities such as abstraction and logical analysis. Outcome data for the REHABIT program have been limited (Brodsky, Brodsky, Lee, & Sever, 1986).

In terms of methods for remediation of specific cognitive deficits, Sohlberg and Mateer’s (1989, 2001) popular Attention Process Training (APT/APT-II) series is one of a very few comprehensive approaches to the retraining of a specific area of cognition that has gained attention. This approach is based on a hierarchical model of attentional abilities, which range from simplest to most complex. The components of the model, in order of increasing complexity, include: focused attention, sustained attention, selective attention, alternating attention, and divided attention. Sohlberg and Mateer’s hierarchical model underlies and guides their approach to the rehabilitation of attention. For example, a patient’s attentional abilities are assessed in each of the domains, then rehabilitation focuses first on the lowest levels of attention that are found to be impaired. As lower level skills improve through a variety of training exercises, more complex skills are practiced/remediated until patients reach their highest
Robertson (1996) proposed a specific cognitive retraining model for addressing executive dysfunction called the Goal Management Training method. This program trains patients with executive dysfunction to master five "stages" or steps, which are aimed at first reducing impulsivity and then helping patients plan, organize, perform a task, and then check their work after the task is completed. The clinical utility of this approach has been shown in the rehabilitation of frontal lobe dysfunction in adults (Carter et al., 2000; Levine et al., 2000, 2011) and children (Metzler-Baddeley & Jones, 2010).

Clearly, progress is being made in terms of the development of models for rehabilitating attention and executive functioning. But what of other areas of cognitive function? Unfortunately, although there are many articles that discuss different methods and ideas regarding retraining visuospatial and language functioning (Rohling et al., 2009), as well as sensorimotor functions (Pichiorri et al., 2011), no one, to date, has published a comprehensive method for retraining these abilities that has been well validated and gained widespread acceptance.

Memory is another area in which there is not yet a widely accepted or comprehensive rehabilitation model, but there has been substantial clinical and experimental work in this area, which has guided the development of various individual methods. Methods such as errorless learning, spaced retrieval, and vanishing cues and compensatory strategies such as mnemonics and visualization/imagery techniques are used by clinicians in rehabilitation with some frequency. Among the more recent class I evidence available, errorless learning has been shown to be particularly effective (Cohen, Ylvisaker, Hamilton, Kemp, & Claiman, 2010; Lloyd, Riley, & Powell, 2009; Wilson, Baddeley, Evans, & Shiel, 1994) and was recently noted as having sufficient scientific evidence backing its relative advantages over errorful (e.g., trial-and-error) learning and error reduction strategies (Piras, Borella, Incoccia, & Carlesimo, 2011). Cicerone et al. (2011) note, however, that errorless learning in severely injured persons is often limited in terms of transfer to novel tasks or reduction in overall functional memory. Piras et al. (2011) also indicated that spaced retrieval and the method of vanishing cues were “potentially effective” rehabilitation methods, based on currently available scientific evidence. Compensatory strategies were found to have evidence of “probable effectiveness” for persons with moderate or severe memory impairment after TBI or stroke (Cicerone et al., 2011).

Criteria for Modern Rehabilitation Approaches

In practice, CR approaches now tend to focus on one or more conceptual criteria that generally map onto the three principles of rehabilitation first posed by Zangwill (1947): substitution, compensation, and direct training. For example, a rehabilitation program may seek to improve cognitive function primarily through repetitive, systematic, hierarchical restorative cognitive stimulation (e.g., Sohlberg & Mateer’s APT series). Alternatively, a program may choose to teach compensatory strategies that target actual task performance or train patients to substitute a new method for their former, impaired approach. In 2005, Cicerone and colleagues published a landmark article in which they reviewed 47 CR studies, concluding that retraining is effective for some cognitive functions (e.g., language, attention), whereas compensation appears to be most effective for others (e.g., memory).

Another conceptual dimension rehabilitation programs must consider concerns the content of the treatment tasks themselves (Rizzo & Buckwalter, 1997). Some programs choose to focus on the training of component cognitive processes such as attention or memory, whereas others emphasize functional skills training such as practicing a standard set of steps in a work routine. Cognitive rehabilitation approaches can also be contrasted in terms of whether they are more person centered or environment centered. Environment-centered approaches are most effective when a patient is not capable of learning new functional skills and changes in his/her environment are needed to maximize function/independence. In reality, most CR programs
are flexible and match the rehabilitation approach(es) to the needs of the patients they serve (Parente & Herrmann, 1996; Sohlberg & Mateer, 1989).

The Unique Contribution of Neuropsychology to CR

It has been previously noted that CR is a multidisciplinary enterprise. The professional diversity that comprises the field of CR is a significant strength in many ways, though having so many different perspectives may be a disadvantage when it comes to the development of uniform models and methods for treatment. Nevertheless, there is one dimension in which neuropsychologists are particularly well positioned to contribute to the development of the field of CR. Most practicing neuropsychologists in North America are trained first as clinical psychologists, with additional predoctoral and postdoctoral training in neuropsychological techniques. Because of their training, they have expertise in emotional functioning, personality, and the impact of these on behavior. As a result, among all the professionals working in the CR field, neuropsychologists are perhaps the best equipped to understand and address the emotional responses of the patients with whom they work.

Emotional difficulties are very common among brain-impaired persons, perhaps because an individual who has suffered a brain injury has suffered a significant personal loss and may have experienced some emotional trauma associated with the injury. It should not be surprising, then, when a brain-injured person exhibits depression, anxiety, posttraumatic stress disorder (PTSD), or other emotional reactions. In 1996, Kopelman and Crawford found 40% of 200 consecutive individuals referred to a memory clinic were suffering from clinical depression. Similarly, Bowen, Neumann, Conne, Tennant, and Chamberlain (1998) reported that 38% of 99 hospitalized TBI survivors had clinically significant mood disorders. Neurobiological changes, declines in functional capacity (physical and/or cognitive), psychosocial changes, and psychological responses to these changes can all play important roles in the development of emotional dysfunction after injury. Professionals who work in the CR field quickly become familiar with the negative impact emotional dysregulation, mood disorders, anxiety disorders, grief, and other emotional reactions can have on recovery. In some cases, these issues become more prominent than the cognitive dysfunction for which the patient is being treated in rehabilitation, and progress can slow or even grind to a halt as a result of such factors.

Wilson (2008) alluded to the unique contribution neuropsychologists have to make in the process of rehabilitation when she described neuropsychological rehabilitation as a broader field than CR because it encompasses “the amelioration of emotional, psychosocial, and behavioral deficits caused by an insult to the brain” in addition to cognitive remediation. Indeed, holistic CR models—models that incorporate treatment of psychosocial and emotional difficulties experienced by brain injury survivors with cognitive remediation and compensation training—are increasingly being studied and recognized as effective treatment approaches (Ben-Yishay & Daniels-Zide, 2000; Cicerone et al., 2008; Rattok et al., 1992). Prigatano (1999) went so far as to suggest that rehabilitation is likely to fail if clinicians do not deal with emotional issues with their brain-injured patients; he has become a well-known proponent of psychotherapeutic treatment for brain injury survivors.

Despite growing recognition that psychotherapy services are not simply a nice “add-on” to rehabilitation, but are an integral part of treating the brain injury survivor, there is very little literature regarding the development (or adaptation) of specific models of psychotherapy for use in conjunction with CR programs. A review of the available literature via PubMed, PsychInfo, and MEDLINE revealed only three studies that have reported results from the integration of psychotherapy with CR for cognitively impaired persons. One involved mindfulness meditation therapy (McMillan, Robertson, Brock, & Chorlton, 2002), although it was noted that their brief intervention was not particularly helpful in alleviating mood or cognitive symptoms in TBI. In 2005, Mateer, Sira, and O’Connell discussed ways in which specific cognitive–behavioral therapy interventions were utilized with patients undergoing CR. They specifically targeted symptoms such as catastrophic thinking (e.g., a distortion in which a person imagines the worst possible outcome of an event or situation) or becoming hypersensitive to one’s error rate in functioning due to failure to distinguish...
between “normal,” ordinary errors in functioning and more serious errors that are likely caused by brain injury. In doing so, they presented a case report of one such successful integration of cognitive behavioral therapy (CBT) and CR with a mild TBI survivor. Tiersky et al. (2005) also demonstrated the usefulness of providing both CBT and CR on emotional functioning as well as improved attentional capacity at the conclusion of an 11-week program with TBI patients in a single-blind randomized, wait-list controlled trial. Utilizing a psychodynamic approach, Ben-Yishay and Daniels-Zide (2000) presented a thoughtful treatise on the importance of not only recognizing disruption in a patient’s sense of self (“ego identity”) after injury, but also the enormous difference it makes in functional outcomes when he/she is helped to rebuild a fractured ego identity during the rehabilitation process. Overall, there remains much work to do in the area of psychotherapy/CR integration.

**Use of Technology in CR**

Neuropsychologists working at rehabilitation centers today increasingly have access to sophisticated technology that assists them in their understanding of the extent and nature of their patients’ brain damage and in their treatment of their patients. Indeed, the process of rehabilitation itself is becoming more and more infused with the use of technology each year. For example, 20 years ago, it was common for neuropsychologists to train memory-impaired patients to use “memory notebooks” (typically small three-ring binders) as a means of remembering appointments and other important information. When handheld electronic devices such as personal organizers and cell phones became ubiquitous at the turn of the 21st century, neuropsychologists quickly adapted, incorporating these cognitive prosthetics into the rehabilitation process. Today, many patients are encouraged to use Smart phones, iPads, personal computers, and many other types of computerized devices in the rehabilitation process.

The value of computerized skills training programs is well established in CR for a variety of populations. Over 20 years ago, Larose, Gagnon, Ferland, and Pépin (1989) provided 12-hour computerized attention training to 60 subjects with varying degrees of cognitive deficit. Results revealed improvements in attentional functioning for all subjects, regardless of their initial level of attentional capacity. Westerberg et al. (2007) demonstrated the effectiveness of computerized training of attention and working memory with stroke patients. Flavia, Stampatori, Zanotti, Parrinello, and Capra (2010) showed that a 3-month course of intensive computer-assisted CR was effective in improving the attention, information processing speed, and executive functioning abilities of mildly impaired patients with multiple sclerosis. Cognitive remediation using computers has also been shown to be effective in improving the cognitive functioning of patients with schizophrenia (Eack et al., 2009).

Computerized rehabilitation has also been utilized successfully in pediatric populations, though there are far less data available in this area. For example, success has been reported using eight- to ten-session computerized rehabilitation programs to improve the attention and maze learning abilities of children with HIV-related cognitive impairment (Boivin et al., 2010) and in children with cerebral malaria (Bangirana et al., 2009). Similarly, Kesler, Lacayo, and Jo (2011) demonstrated improvements in processing speed, cognitive flexibility, and declarative memory in pediatric cancer survivors who participated in an 8-week computerized program.

As computer technology becomes increasingly sophisticated, virtual reality (VR) programs have been developed and applied to rehabilitation. Many have hailed VR as a tool with tremendous possibilities for rehabilitation. Critics feel that VR is a potentially exciting tool for rehabilitation, “but its evidence base is too limited by design and power issues to permit a definitive assessment of its value” (Crosbie, Lennon, Basford, & McDonough, 2007). Despite the limited VR data available to date, early reports suggest promise, as it has been shown to improve visual processing, visual learning, and reaction time in a preliminary sample of brain injury survivors (Grealy, Johnson, & Rushton, 1999).

In particular, VR technology appears to be promising in its ability to deliver ecologically valid rehabilitation outcomes. For example, VR rehabilitation has been shown to be effective in training students with severe learning disabilities how to shop in a virtual supermarket, with generalization of those skills to the real world (Cromby, Standen, Newman, & Tasker, 1996).
Cox et al. (2010) described a VR program that was designed to help brain-injured military personnel relearn driving skills. After 4 to 9 hours of driving simulation training, subjects participating in the program demonstrated significantly better driving skills, fewer risky driving behaviors, and fewer road-rage behaviors than subjects who had been treated with residential rehabilitation treatment only. Yip and Man (2009) reported success in teaching community living skills (e.g., using public transportation or shopping) and memory performance with four acquired brain injury (ABI)/stroke patients using a 10-session, VR-based community living skills training program.

Another new use of technology in neuropsychological rehabilitation is telerehabilitation—the remote administration of rehabilitation consulting, monitoring, and/or treatment via telecommunications/video transmission. To date, the telerehabilitation literature is limited, but is indeed growing and promising. In one of the earliest studies, Lemaire, Boudrias, and Greene (2001) conducted physical medicine consultations via videoconferencing and reported good overall satisfaction with procedures. Forducey et al. (2003) used telerehabilitation in a patient with severe TBI who lived in a nursing home in a remote area and reported improvements in his physical and cognitive status. We were able to identify only one study that reported on CR via videoconferencing (Peel, Russell, & Gray, 2011), although this was focused on elderly patients receiving rehabilitation in their homes. Nevertheless, this method of providing rehabilitation services will certainly continue to expand, both in terms of the use of videoconferencing-based as well as home- or Internet-based interventions (see Chapter 19 by McCue and Cullum).

FUTURE DIRECTIONS FOR NEUROPSYCHOLOGICAL REHABILITATION

Those who work in the field of neuropsychological rehabilitation owe a debt of gratitude to all those scientists and clinicians who have contributed to our understanding of brain function and rehabilitation. Although much progress has been made, it is clear that there is still much that we do not know and much more to be done in this field. Some of the challenges for neuropsychological rehabilitation going forward include:

- *Continued development of conceptual models of CR*. Clinical practice without a guiding theory is simply a collection of techniques. Systematic models of CR are needed that will lead to sound, cohesive treatment programs. These programs must also be subjected to empirical study to ensure that we are utilizing evidence-based methods rather than simply using techniques that “make sense,” that patients “like,” or which are comfortable because of their familiarity.

- *Increased emphasis on evidence-based interventions and improved CR research*. Cognitive rehabilitation programs need to be replicable and utilize state-of-the-art methodologic designs that will result in more published research. With advances in our ability to phenotype and genotype individuals using a variety of procedures, future goals should include the development of personalized CR programs based upon research that can help identify which patients may benefit most from specific CR intervention strategies.

- *Greater focus on the integration of CR and psychotherapy*. The importance of making psychotherapy services available to patients undergoing CR seems obvious; however, many patients still do not receive adequate attention to their emotional status. Identification of emotional issues is the key, and those who suffer more quietly or have more subtle emotional difficulties may not receive adequate treatment.

- *Incorporation of neuroimaging with neurocognitive techniques*. Strangman and colleagues (2010) recently reported that regional gray matter volumes could be used to predict memory outcomes following a specific 12-session group memory training intervention (O’Neill et al., 2010). Brain regions that were most associated with memory outcome included the hippocampus, prefrontal regions, thalamus, and areas of the cingulum.

- *Continued development of advanced technology applications*. Cognitive rehabilitation will continue to creatively utilize new technology. Virtual reality and telerehabilitation...
are but two of the newer, exciting areas in which CR advancement will undoubtedly continue. Recent studies have already demonstrated the feasibility and validity of telemedicine-based neuropsychological assessment (Cullum, Weiner, Gehrmann, & Hynan, 2006), and CR programs are increasingly incorporating such technology into evaluation and treatment protocols (see Chapter 19 by McCue and Cullum). Obviously, all new CR technologies and methods will need to be carefully evaluated for efficacy before they can enjoy widespread acceptance; however, it is with optimism and excitement that rehabilitation professionals look to the future and the development of these new ways of offering hope and relief from suffering to those patients who experience brain insults.

REFERENCES


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