Rehabilitation of Attention and Concentration Deficits Following Brain Injury

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Attention is the ability to focus on certain aspects of the environment that one considers important or interesting and to flexibly manipulate this information (Sohlberg & Mateer, 1987; Wood, 1988). Arousal and alertness are prerequisites for attention. Attention, in turn, is a prerequisite for memory, communication, and executive brain functions, although these cognitive processes will in turn determine to what we attend.

Attention can be viewed as an organizing force for all behavior. As such, it encompasses the abilities to receive information, to select what is relevant from the incoming stimulation, to persevere at and complete an activity, and to change course when appropriate. Many aspects of frontal lobe function (and dysfunction) are increasingly being interpreted in attentional terms. Attention thus performs a pervasive role in enabling a person to successfully complete diverse cognitive, personal care, social, and educational/vocational activities. Behavioral changes observed after brain injury are often rooted in attentional dysfunction (Bennett, Dittmar, & Ho, 1997).

Levels of Attention

Five levels of attention have been described that can be adversely affected by traumatic brain injury. (Sohlberg & Mateer, 1987; 1989; Van Zomeren, 1987):

1. Focused attention is the ability to perceive individual items of information.
2. Sustained attention is commonly called concentration, which predominantly involves vigilance.
3. Selective attention is the ability to avoid distractions from both external (e.g., noise) and internal (e.g., worries) stimuli.
4. Alternating attention is the ability to shift the focus of attention and to alter it between tasks. After brain injury, attention may become rigid or inflexible, especially if the individual is unable to remove his or her attention from the task as needed (Buchtel, 1987; Trexler, 1982; Van Zomeren, 1987).
5. Divided attention is the ability to respond to multiple tasks at the same time, and as one would expect, this is much more difficult to accomplish within the same modality (e.g., vision) as it is between modalities (e.g., vision and audition; Rojas, 1995).

These five categories of attention can function in either a conscious or automatic mode (Shiffrin & Schneider, 1977; Wood, 1988), although most tasks require a combination of both. Conscious attention is slow and effortful, requires focus and concentration, and involves serial processing (i.e.. when learning a new skill, or solving a problem). On the other hand, automatic attention is rapid and involves parallel processing (i.e., when performing a learned skill).

Daily Attentional Changes

As discussed by Malia, Bewick, Raymond and Bennett (1997), there is convincing evidence that links biological rhythms with arousal and attention. Circadian rhythms, which are approximately 24-hour cycles, are one type of biological rhythm. Apparently, different circadian rhythms occur for different cognitive processes and even for different aspects of attention (Folkard, Marks, Minors, & Waterhouse, 1985). For example, conscious or effortful attention processes are typically good in the morning, diminish after lunch, and rise again in the afternoon, whereas automatic attention processes apparently do not fluctuate during the day (Testu, 1986). Generally, arousal and vigilance begin at a low level during the morning and gradually improve to a peak level in the evening (Blake, 1967; Tilley & Warren, 1983). It is apparent that traumatic brain injury can alter these biological rhythms (McIntosh, 1987). Thus, disruption of these rhythms may be one of many factors contributing to attention deficits in individuals with brain injury. Brain injury rehabilitation must consider daily fluctuations in these cognitive processes in designing programs that will maximally facilitate recovery.

Attention Deficits Following Brain Injury

The major cognitive sequelae that are present after traumatic brain injury may include decreased speed and efficiency of information processing, disrupted attention and concentration, problems with learning and memory, perceptual disturbances. disorders of communication, difficulties with executive cognitive functions, and decreased general intelligence (Bennett, Dittmar, & Ho, 1997). Clarification of the presence, severity, and contribution of each cognitive deficit to the presenting symptoms of an individual with traumatic brain injury is dependent, of course,

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on a thorough evaluation consisting of clinical interviews, behavior observations, and performance on brain-injury-sensitive neuropsychological tests. In our own practices and centers, we generally use an expanded Halstead-Reitan Neuropsychological Test Battery for the latter purpose (Bennett, 1988).

Attention deficits are recognized as one of the most common problems associated with brain injury (Bennett, Dittmar, & Ho, 1997; Geschwind, 1982; Wood, 1987). Almost all individuals with brain injury report that it takes more cognitive effort to pay attention, that they suffer from a shorter attention span, and that they are more distractible. Most of them will complain that they are unable to do more than one thing at a time, or they will report being unable to deal with more than one idea or a task simultaneously. When environmental stimulation and demands are high, they will report a sense of "overload" or "shutting down."

Many of the complaints of an individual with traumatic brain injury are based on such problems, but attention and concentration difficulties are also in turn related to such brain-injury-related deficits as decreased speed and efficiency of information processing or decreased information processing capacity. In general, if attention is compromised, information is not properly processed by the brain, and this will result in reduced understanding and misuse of information. In turn, this can produce problems with communication, social awareness and judgment, self-awareness and insight, memory, and initiation, follow-through, self-monitoring and correcting, and completion of activities.

Areas of the Brain Involved in Attention

Attention is affected by damage to any area of the brain, and from a pathophysiological standpoint, the cognitive deficits that we observe in individuals with traumatic brain injury reflects a combination of focal brain injury and diffuse axonal injury (Bennett, Dittmar, and Ho, 1997). Basic arousal and alertness are dependent on brain stem mechanisms; loss of consciousness and coma reflect a disruption of brain stem structures involved in arousal. Without a sufficient arousal level, there can be no attention. An excellent discussion of neural mechanisms of attention, as well as a discussion of disorders of arousal and attention, can be found in a book edited by Cohen (1993).

Incoming environmental stimulation results in activation of the central brainstem arousal system in the vicinity of the reticular formation. Information is then relayed, via the various sensory pathways, to the thalamus from which signals travel to appropriate sensory receiving and processing regions of the cortex. Injury to the cerebral cortex can result in sensory specific, as well as generalized, attention deficits. Frontal-temporal brain injury can result in difficulties in sustained, focused, and alternating or divided attention. Such injuries can result in alterations of higher level behavior processes, such as poor self-monitoring, impaired awareness, inflexibility of thinking, response perseveration, and impaired social awareness and responsivity (Malia, Bewick, Raymond, & Bennett, 1997). Parietal lobe injuries, especially to the right hemisphere, can result in unawareness syndromes that are often interpreted as being attention based.

Assessment of Attention

Contingent upon the degree and severity of the brain injury, attention deficits may persist for an extended period of time, even for years. Prior to treating attentional disorders, it is important, as it is with other cognitive disorders, to formally evaluate this cognitive process. Assessment will assist in providing a better understanding of how the attention difficulties are affecting a person in his or her activities of daily living, and assessment will aid in developing the most appropriate rehabilitation strategies for the brain injured individual.

Since attention contributes to the success of any cognitive activity, most cognitive or neuropsychological tests used to evaluate brain functions contain a general attention component. Attention processes are assessed directly via tests that evaluate speed and efficiency of processing and tests that evaluate attention and concentration. As indicated, we generally use an expanded Halstead-Reitan Neuropsychological Test Battery (HRNTB) in our practice settings to evaluate cognitive capabilities following traumatic brain injury. The following neuropsychological tests, including patterns of performance, are commonly used to evaluate possible deficits in speed and efficiency of processing and levels of attention:

Speed and Efficiency of Information Processing:

- timed tests such as the performance subtests of the Wechsler Adult Intelligence Scale-Revised (WAIS-R), particularly in those cases in which the person can do the task but not in the required time
- relatively impaired performance on the Seashore Rhythm Test as compared to the Speech Sounds Perception Test (HRNTB)
- slow performance on tests of visual scanning including

Digit Vigilance, Stroop Neuropsychological Test, or Trails A (HRNTB)
- increased difficulty, compared to normal performance, as the interstimulus interval decreases on the Paced Auditory Serial Addition Task (PASAT)

Focused attention:
- all attention tests require focused attention

Sustained attention:
- WAIS-R Digit Span, (forward and backward), arithmetic, and Digit Symbol subtests
- Speech Sounds Perception Test and Seashore Rhythm Test (HRNTB)
- PASAT
- Knox Cube Test
- Corsi Block Test
- Trails A (HRNTB)
- Wisconsin Card Sorting Test, failure to maintain a correct strategy

Selective Attention:
- Digit Vigilance test
- Stroop Neuropsychological Test
- Wisconsin Card Sorting Test, number of categories completed
- Gordon Diagnostic System Vigilance and Distractibility subtests

Alternating and/or divided attention:
- relatively greater impairment of Trails B as compared to Trails A (HRNTB)
- WAIS-R Digit Symbol subtest
- Symbol Digit Modalities Test
- PASAT

Implications of Deficits on Tests of Attention and Concentration for Functional Activities of Daily Living

As discussed by Bennett (in press), deficits on tests of attention and concentration can in general facilitate our understanding of how a person's brain injury is affecting functional activities of daily living. Limitations from the testing do arise, however, and these are secondary to the structure and sterility of the testing environment and a failure to consider qualitative behavioral observations along with quantitative data (test scores). These limitations may underestimate the degree of neuropsychological impairment in individuals with brain injury. As Sbordone (1996) has emphasized, the testing room is not the real world, and the testing environment is set up so that performance will be maximized. The room is free from the typical distractions of the real world, and on most tests, the person is allowed to work at his or her desired pace. This can result in a person appearing to have significantly better attention and concentration skills than is actually the case. That is, our testing procedures do not always have good ecological validity (relevance to real life).

It is also important to observe a person's behavior closely during assessment. A person may be using compensatory strategies to achieve good scores, but these strategies might not approach the effectiveness of normal brain functions in cognitive processes. Thus, if a person obtains a "normal" score on a test of attention but does so in such a way that would not work in normal activities of daily living, then the person is still impaired neuropsychologically and functionally.

As emphasized, attention and concentration are critical for overall neuropsychological functioning, and if deficits are present in these core areas, then individuals with brain injury will typically also report difficulties in learning efficiency, memory, communication, reading and writing, and problem solving. Some examples of the implications of specific test scores on functional performance are as follows (Bennett, 1988; in press).

With respect to sustained attention, individuals who perform normally on the Speech Sounds Perception Test, but poorly on the Seashore Rhythm Test, can typically stay on task or track a conversation in a slow-paced, quite environment, but they will lose tract of a conversation or what they are doing if the pace quickens or if distractions increase. People who make most of their errors on page two of the Digit Vigilance Test have trouble sustaining their attention and processing information for more than a few minutes; they need information presented in small chunks, and they need frequent cognitive breaks in the workplace or during conversations. Tracking lectures is very difficult for students who do poorly on this task.

People whose basic attention skills appear to be adequate but who have trouble maintaining a correct strategy (sorting principle) on the Wisconsin Card Sorting Test are particularly sensitive to outside interference (distractions) as they go about their daily activities. They need to work in an environment that is relatively free from distractions. Individuals who perform normally on Trails A (good sustained attention) but poorly on Trails B (impaired alternating and/or divided attention) have trouble shifting their attention between several activities. An example would be the receptionist at a doctor's office who must answer several phone lines while keeping track of patients checking in, making appointments, and filing charge forms. A person who has significant relative difficulty on Trails B must stay on a single activity until it is completed. In general, such individuals have trouble "thinking on their feet."

Rehabilitation of Attention and Concentration Deficits

Rehabilitation of attention and concentration deficits are central to cognitive rehabilitation, and overall cognitive improvement in brain injured individuals is reflective of improvement in these key cognitive abilities. Although attention is often the general area of impairment which is addressed in cognitive rehabilitation, it must be broken down into it's component parts in order to be effectively remediated. In order for the client to effectively apply knowledge and strategies to his/her life, he/she must first acquire a solid sense of awareness regarding his/her own difficulties as they relate to attention/concentration, information processing, speed and accuracy, memory and learning, perceptual disturbances, communication disorders, difficulties with executive functions and decreased intelligence. This metacognitive awareness training is therefore the umbrella under which the entire cognitive remediation process should be executed (Bewick, Raymond, Malia, & Bennett, 1995).

Three hierarchical levels of awareness have been described

by Cross on et al., 1989, as follows:

1. Intellectual Awareness: This is the client's awareness that his/her performance has changed from its premorbid baseline. Clients state that they "Just can't get it together," "I get so tired," or "I can't follow conversations."
2. Emergent Awareness: This is when a client can identify a problem while it is occurring. If the client does not recognize when the problems are occurring, he/she is unable to apply compensatory strategies.
3. Anticipation Awareness: This is when a client is able to project or anticipate that a problem is going to occur as a result of their deficit.

It is the function of the treatment team to facilitate the client's progression through these stages of awareness and provide strategies to help him/her cope with the effects of the injury in his/her life. The key to the success of attention rehabilitation, however is centered around the methods used for ensuring generalization.

The cognitive rehabilitation program at the Brain Injury Recovery Program is based on the philosophies of Sohlberg and Raskin (1996) regarding generalization strategies for attention and memory interventions. They have identified the following methods which, when used in combination with a client centered program, have been effective in the rehabilitation of cognitive impairments following brain injury. These methods include:

1. Process Specific Rehabilitation (i.e., attention process training)
2. Skills Based Training (i.e., prospective memory training)
3. Compensatory Strategy Training. (i.e., compensatory memory techniques)
4. Metacognitive Awareness Training (i.e., cognitive process awareness and strategy training)

It is not enough, however, to simply guide the clients through these methods. The therapist must also have in mind principles of generalization from which to work. Sohlberg and Raskin describe five principles of generalization which form the framework upon which our rehabilitation programs are based. These principles and methods provide a sound basis from which the therapists can assist the client's progression throughout the rehabilitation process. These principles are as follows:

1. Actively plan for and program generalization from the beginning of the treatment process.
2. Identify reinforcements in the natural environment.
3. Program stimuli common to both the training environment and the real world.
4. Use sufficient examples when conducting therapy.
5. Select methods for measuring generalization.

The first three principles of generalization can be addressed during the first two or three sessions of therapy. The client is asked to establish objectives which relate to his/her direct functioning in daily activities; i.e., eating with friends in restaurants, following conversations in groups, balancing a checkbook without becoming distracted, etc. The client subjectively describes his/her abilities to function in these situations before and after therapy which is later used as a measure of generalization as well as a motivation for the client to remain in therapy over time.

Principle four is addressed during therapy sessions which involve repetitive process training and the use of a variety of tasks which stimulates the target cognitive skills. Attention process training, compensatory strategies training, perspective memory, and metacognitive awareness are addressed in this level of the program. A variety of methods can be used to address these areas and include the use of some or all of the following tools/methods:

1. The Attention Process Training Programs (APT; Sohlberg and Mateer, 1987, 1989, 1993). APT includes activities which are designed to remediate attention deficits in persons with acquired brain injury and views attention as the capacity to focus on particular stimuli over time and to flexibly manipulate the information. APT not only addresses the four components of attention processing, but it also assists with the remediation of memory and learning deficits that often result from deficits in attention.
2. Prospective Memory Training (PROMT; Sohlberg & Mateer, 1992). This is the process of training prospective memory skills by gradually and systematically extending the amount of time between task assignment and task execution. It requires repetition and is applied to naturalistic settings to assure generalization. Research has indicated that "drill" oriented approaches to memory remediation are ineffective in improving functional memory behavior in lab and outside settings. We use this skills-based rehabilitation program in conjunction with attention process training, metacognitive training, and the use of compensatory strategy training, to assist our clients in overcoming the effects of their memory impairments.
3. Brainwave-R (Malia, Bewick, Raymond & Bennett, 1997): The purpose of these programs is to facilitate cognitive rehabilitation in clients with brain injury by presenting a multitude of organized therapeutic activities in the primary areas of Attention, Visual Processing, Information Processing, Memory, and Executive Functioning. The initial stages of the modules provide the building blocks upon which thinking, learning, and problem solving are dependent. As the clients progress throughout the programs, more emphasis is placed on real-life skills. Brainwave-R also provides an opportunity for further metacognitive awareness training by having the client complete a prediction-of-performance table prior to the completion of a task. The client is able to compare his/her predicted performance with the actual performance and discuss any differences with the therapist immediately following the task. This immediate feedback builds the clients' metacognitive knowledge and facilitates executive skills, which is the basis for overall cognitive improvement.
4. The Psychological Software Service (PSS) CogRehab Computer Software Program (Bracy, 1994). This program was chosen to assist our clients in reaching a higher level of metacognitive awareness through engaging them in computer activities ranging from simple to extremely complex. The therapist actively participates with the client during these computer activities in order to observe the client's performance and provide immediate feedback and cueing to the client regarding his/her performance. The program contains 4, two-level, cognitive areas which range from attention, visuospatial skills, memory, and problem solving.
5. Communication Group. This group addresses the effects that attention and other cognitive impairments have on a person's ability to communicate with others. Since language and

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