ABSTRACT: This article provides a clinical review of current treatment approaches to short-term and working memory impairments in individuals who have sustained traumatic closed-head injuries. Preliminarily, general information on closed-head injuries is presented. Specific short-term and working memory impairments, as well as assessments and interventions used in the practice of speech-language pathology, are then discussed. Finally, a literature review regarding outcomes and treatment efficacy is presented, revealing potentially limited generalization, though subjective benefits are described. The goal of this article is to prompt clinicians to evaluate their current interventions, thereby maximizing the effectiveness of the therapeutic process and ultimately enhancing the lives of the individuals served.

KEY WORDS: memory, short-term memory, working memory, head injury, brain injury, speech-language pathology

Intervention of Short-Term and Working Memory Impairments in Closed-Head Injury: A Literature Review

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Each year in the United States, an estimated 1.4 million individuals sustain traumatic brain injury, or TBI (Langlois, Rutland-Brown, & Thomas, 2004), which is eight times the number of people who are diagnosed with breast cancer and 34 times the number of new cases of HIV/AIDS, according to the National Center for Injury Prevention and Control at the Center for Disease Control (Thurman, Alverson, Dunn, Guerrero, & Sniezek, 1999). Fifty thousand people die from TBI (Langlois et al., 2004), which accounts for one third of all injury deaths. In addition, at least 5.3 million Americans, 2% of the U.S. population, live with disabilities resulting from TBI (Thurman et al., 1999). Practitioners encountering these significant numbers of individuals must know the underlying anatomy and physiology of TBI, as well as the behavioral, mental, and/or physical changes that may result from head trauma. This knowledge lays the foundation from which rehabilitation professionals most effectively treat the injured individuals.

An injury in which the contents of the skull are not exposed is referred to as a closed-head injury, or CHI, though many coexist with open-head injuries. Rapid acceleration/deceleration is the most common cause of CHI, which involves damage that occurs when the impact of the injury causes the brain to move back and forth against the inside of the bony skull. The injury at the point of impact is called “coup,” whereas a “contrecoup” lesion occurs in the area opposite the blow. Contrecoup damage occurs when the force and direction of impact to the brain, which is in a liquid medium, is translated.

In this type of injury, the frontal and temporal lobes of the brain are the most vulnerable, which are the areas responsible for speech, language, and memory functioning. These areas often receive the most damage because they sit in pockets of the skull that allow more room for the brain to shift and sustain injury.

CHI may also involve disconnection syndromes, which are the ensuing neurobehavioral effects of a disruption in the cerebral connections. These connections include
association fibers (connecting adjacent and distant cortical fibers), projection fibers (ascending and descending fibers connecting the neocortex to the brainstem and spinal cord), and commissural fibers (joining the two hemispheres, including the corpus callosum). An example of a behavioral impairment subsequent to disconnection is an individual who is able to speak but unable to identify printed words or objects because visual information (occipital lobe) is disconnected from the posterior speech area in the left hemisphere.

**MEMORY**

In CHI, neurological damage does not remain within discrete anatomical boundaries, and impaired memory is often a consequence. Memory has been described as processes involving neuronal connections and events that are never observed and always inferred (Kolb & Whishaw, 1990). Memory does not exist within one single place in the brain; rather, groups of neurons are more or less important for recalling certain types of information. Two important types of memory are critical for daily functioning: short-term memory (STM) and working memory (WM). STM involves recalling information for a brief amount of time, approximately 30s to 1 min. WM involves not only temporary storage, but also active manipulation, of the information required for new learning.

The temporal lobes, amygdala, frontal lobes, and diencephalon are four neurological areas that frequently appear in the memory literature, leading to the increasing certainty of the roles of these areas in memory. The temporal lobe has been correlated with memory loss since the turn of the 20th century. Individuals who have endured TBI “have a high incidence of temporal lobe injury (presumably involving the hippocampus and related structures), which may explain the frequent finding of memory disorders in this population” (Umile, Sandel, Alavi, Terry, & Plotkin, 2002, p. 1506). Furthermore, the degree and type of impairment depends on which side of the brain contains the lesion(s). The right temporal lobe is involved in memory processes for nonverbal material (e.g., shapes); the left temporal lobe is involved in memory processes for verbal material (e.g., paragraphs). Therefore, when evaluating memory impairments, one must consider the type of material to be remembered (i.e., nonverbal vs. verbal).

Key memory areas within the temporal lobe are the hippocampus (part of the limbic system that is involved in the formation of new declarative memories, such as facts, figures, and names), entorhinal cortex (major source of hippocampal input and output; where degeneration is one of the primary pathological signs of Alzheimer’s disease), subiculum (sends and receives projections from the hippocampal formation), and amygdala (core part of the limbic system; plays major role in mood and emotion).

The frontal lobes are correlated with the highest intellectual functions, and although lesions have not been classically associated with deficits in standardized tests, they do produce disturbances in memory function. Individuals who have sustained frontal lobe damage have been shown to have an increased susceptibility to interference, poor memory for temporal order, and difficulty with STM for certain material, especially spatial information. Additional effects of frontal lobe damage include difficulty with memory control (i.e., recalling incorrect information) and difficulty developing an effective memory encoding strategy to assist in the learning process (Kolb & Whishaw, 1990). Furthermore, impaired attentional processes are a common result of frontal lobe damage and will likely impact effective memory processing (see “Note on Attention”).

An additional area that has been identified in memory processing is the diencephalon, which consists of the thalamus and hypothalamus. The diencephalon also includes relay centers that evolved in the forwardmost portion of the brainstem. There are two kinds of memory impairments that tend to accompany thalamic lesions and are common in CHI: Learning may be compromised (anterograde amnesia), and recall of past information may be defective (retrograde amnesia). Amnesia refers to the partial or complete loss of memory. Notably, memory-impaired clients with diencephalic lesions lack appreciation of their deficits, and so differ from many other memory-impaired persons (Parkin, 1984). This may make intervention, especially effective strategy implementation, difficult.

**Short-Term and Working Memory**

An all-inclusive discussion of the anatomy and processes of memory is beyond the scope of the present work. Impairments in STM and WM will be the focus of the current discussion due to their common appearance in the CHI population. In addition, STM and WM will be ultimately emphasized as different processes in order to determine and prioritize the most effective intervention for specific deficits. In brief, STM and WM are similar in their involvement with the preliminary brief storage of information necessary for long-term, and thus functional, storage of information (i.e., new learning). However, unlike STM, WM involves the active manipulation of information. In essence, adequate STM (i.e., recall) must exist before WM (i.e., manipulation of the recalled information), so it will be discussed first.

**STM.** STM is commonly affected in individuals who have endured CHI. Kupfermann discussed STM as having a “very limited capacity (less than a dozen items)” (1991, p. 1003). Described in practical terms, Stoler and Hill stated that STM is “critical to daily living; it is what makes it possible for you to recall where you placed your car keys or checkbook” (1998, p. 151). STM involves the processes before the retention and consolidation of information for extended periods of time (i.e., long-term memory [LTM]), from where it can later be retrieved.

Furthermore, STM should be conceptualized as stages of processing, including registration, immediate memory, and primary memory. Clinically, these stages deserve consideration, as clinicians should consider the process in which information transfers from STM to LTM storage to allow new learning, and thus successful daily functioning, to occur.
Looking at the first of these sequential stages of STM, Kupfermann (1991) discussed iconic memory as being a very brief STM for visual events. Iconic memory may also be thought of as registration, or sensory memory, holding incoming information briefly (1–2s) in sensory store. It is thought to be a selecting and recording process by which perceptions enter the memory system.

Immediate memory, another term used to describe the first stage of STM, is described as the process whereby information is temporarily held after being retained from this registration process. Immediate memory serves as a limited capacity store and a limited capacity retrieval system. Rehearsal, which generally enhances this immediate memory, is any repetitive mental process that serves to lengthen the duration of a memory trace. In other words, rehearsal increases the chances that the information will be permanently stored.

Primary memory refers more to the processing nature of this type of memory than to an actual store. In other words, primary memory refers to the activation of a memory trace for further encoding, which involves processing stimuli in order to transform it into a perceptual or conceptual form to be stored in LTM. Overall, information either is further processed as STM or quickly decays. Anything we remember has had to go through a process such as rehearsal in order to have transitioned to our LTM from first being a brief sensory phenomenon. Any or all of these preliminary stages may be interrupted in CHI and may present as impaired STM, characterized by the overall inability to organize information for initial storage.

WM. In contrast, WM is relevant to situations in which one must recall, manipulate, and transform information before responding. For instance, the WM task of backward digit span, or repeating a series of digits backwards, involves active manipulation of material, or the simultaneous storage and processing of information. Contrast this to forward digit span (i.e., repeating numbers), which is considered STM, as nothing must be done to the material beyond simple recall. In other words, what distinguishes WM from STM is the processing and manipulation of information that occurs in WM.

Baddeley (1986, 1992) postulated two WM subsystems: the phonological loop, for processing the sounds of language, and the visuospatial sketchpad, for visual information. These two subsystems thus involve different types of material to be recalled. The phonological, or articulatory, loop is responsible for the temporary storage of verbal material, where material is verbally and subvocally rehearsed. An example would be hearing a nonsense word and repeating it back. An example of a task involving the visuospatial sketchpad would be to reproduce a design after being briefly shown it.

Several authors have described how memory impairments following CHI may be specifically attributable to WM impairments and the impact of anxiety following injury. Richardson stated that resulting cognitive self-concern following injury may lead “to a reduction in the available capacity of...working memory” (1990, p. 127). Richardson and Snape (1984) used tasks requiring recall of concrete and abstract words and discovered that the pattern of impairment was found to be attributable to a specific problem in the use of WM. Individuals tested within a few days of their accidents were found to be severely impaired compared to the other group who were tested as outpatients several weeks later. This was precisely the outcome that was expected based on the understanding of stress and anxiety on learning and memory; Richardson and Snape thought WM impairments were due to impaired storage capabilities.

**Learning.** The concept of learning provides an effective means of summarizing the potentially devastating functional effects of STM/WM impairments. “Learning is the process of acquiring knowledge about the world. Memory is the retention or storage of that knowledge” (Kupfermann, 1991, p. 997). Without adequate STM/WM functioning, the acquisition and retention of new information is severely compromised. New information must be effectively processed in STM and WM in order to be transferred and stored in LTM to demonstrate new learning. Thus, if an individual with STM/WM impairments is unable to learn new information, functional daily living, and potentially safety, are significantly compromised.

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**IMPACT OF SEVERITY OF HEAD INJURY ON DAILY FUNCTIONING**

Considering the severity of an injury will help to predict the extent to which an individual is likely to encounter difficulties related to memory function in his or her daily life. Therefore, it may be helpful to discuss STM impairments in relation to severity of injury.

**Severe**

As previously discussed, STM impairments from severe head injuries may be characterized as difficulties in the acquisition (learning) of information. In other words, severe STM impairments will not allow information to be transferred into LTM. If the information cannot be stored, it cannot be retrieved at a later time.

Functionally, severe memory impairments subsequent to CHI may present as an individual’s inability to recall someone that he or she just met or an event that just occurred. In other words, the person may be said to have no minute-to-minute, or day-to-day, memory. In extreme cases of severe CHI, memory disorders may significantly limit the individual to awareness of only what is immediately present. Thus, these severe impairments are not likely to benefit from any cuing and constitute extreme functional deficits.

**Mild**

In contrast, individuals with mild memory deficits following CHI may function well in simple tasks of daily living, but may experience difficulty during tasks in certain environments that require higher level cognitive processes (e.g., school or work). Mild deficits may appear as borderline
scores, or even within normal limits, on standardized tests due to the structured contexts of such tests. In contrast to severe impairments, these mild deficits may benefit from cuing to assist in recall (e.g., providing multiple choices to assist the individual in recalling correct answers).

Attention and Retrieval Deficits

In cases of mild CHI, individuals may complain of impaired STM; however, this common complaint may be more the result of attentional deficits, specifically, reduced span and increased distractibility. As Chuah, Maybery, and Fox (2004) discussed, individuals with mild head injury can demonstrate evidence of subtle impairments of attention and increases in distractibility that persist many years following injury. The authors discuss how deficits on STM tasks may be related to attention deficits. Consider the individual who is initially attempting to recall information but is continuously distracted by background noise, and thus has significantly decreased recall. A second trial is given in a quiet environment, and this same individual now has no difficulty recalling the information. Generally speaking, then, if one cannot attend to the information, one will not recall it later.

Along with attentional deficits, an individual may also have retrieval deficits (Lezak, 1995). Verbal retrieval problems (dysnomia) may be misinterpreted as some form of memory or learning disorder (Richardson & Snape, 1984); however, they can be distinguished by using cuing or recognition strategies, enabling the individual to demonstrate that he or she knows the word or name (i.e., recall vs. vocabulary deficits). Therefore, due to coexisting retrieval and/or cognitive (e.g., attentional) impairments, the ability to effectively use cuing to assist in recall may be an important factor in determining the presence of mild memory deficits in an individual who has sustained CHI.

Overall, impairment of retrieval should be differentiated from impairments in STM/WM. If the individual can recall new information following cues, this indicates that the information had been stored (i.e., processed beyond STM/WM) but required cuing to retrieve (i.e., deficits in retrieval vs. in STM or WM). Deficits in retrieving the information from memory are very distinct from impairments in initial storage. This differentiation has great implications for intervention as cuing and other strategies may be used to retrieve the information. On the other hand, if an individual has difficulty processing the information in STM/WM, strategies should be employed to successfully allow the information to be processed initially.

The Memory Assessment Scale

Most cognitive batteries have sections for memory; however, the clinician may want a more detailed assessment of specific memory deficits. Although many useful memory assessments exist in clinical practice today (e.g., Randt Memory Test, Randt & Brown, 1983; Rivermead Behavioural Memory Test, Wilson, Cockburn, & Baddeley, 1985), the Memory Assessment Scale, or MAS (Williams, 1991), is described here due to its examination of different types of memory and inclusion of delayed recall subtests, as well as the functional implications that may be drawn from the test results.

The MAS is a comprehensive and standardized memory assessment battery consisting of 12 subtests that measure three major areas of function: (a) attention, concentration, and STM; (b) learning and immediate memory; and (c) memory following delay. For all of these areas, separate verbal and nonverbal tasks are used to measure material-specific (i.e., verbal vs. visual) memory. Measures of recognition, intrusions during verbal learning recall, and retrieval strategies are also included. Specifically, the MAS helps determine whether an individual can recall verbal information in the form of a list of random words and short paragraphs, both immediately (short-term verbal memory) and following delay. STM and WM are measured with spans of digits forward and backward. Visual STM is assessed as the patient is required to point immediately to pictured stimuli in the same order as the examiner, as well as to immediately recall and reproduce visual stimuli. Recall of names associated with pictures is also tested with multiple choices, both immediately and following delay.

In addition to the 12 subtest scores, three summary scale scores and a global memory scale score (i.e., general memory ability) are provided. Clinicians will determine the severity of deficits in the general categories of verbal, STM, and visual memory and may devise therapeutic tasks that maximize strengths in one area to promote improvements in another (e.g., using verbal memory strengths to create verbal labels for visual information to be recalled).

Results of the MAS indicate specific areas warranting intervention and will subsequently lead to effective
treatment planning. For instance, if an individual is only able to immediately list 3 out of 12 random words, is unable to list any digits backward, and is unable to immediately recall any information from a short story, intervention should focus preliminarily on improving STM and WM. Specifically, to address STM, treatment for this individual may include immediately recalling longer sequences of numbers and words (beginning with 3 as the baseline), and once adequately achieved, improving the ability to manipulate the information, or WM (“Now recite them backward”).

**Note on Attention**

It should also be considered that attention precedes memory functioning; that is, if attention deficits are present, the individual will generally present with memory deficits due to the close coexisting relationship of these two cognitive processes. Clearly, adequate evaluation of attention is also warranted, including sustained attention (maintaining consistent behavioral responses for a time period), selective attention (maintaining a behavioral or cognitive set in the presence of distracting stimuli), alternating attention (mental flexibility or shifting focis), and divided attention (responding to one or more tasks or stimuli). Readers are referred to Sohlberg and Mateer (2001), who provide standardized measures of attention, and also to Chan (2002), who suggests a multicomponential framework consisting of sustained, selective, and divided attention, as well as attentional control processing. The latter author concluded that persons with mostly mild head injury demonstrated impaired performance involving multiple aspects of attention.

**Note on Real-Life Validity of Standardized Tests**

It must also be noted that standardized laboratory results have been described as not corresponding well with the numerous memory requirements of daily life. In their chapter regarding assessing everyday memory after severe head injury, Sunderland, Harris, and Baddeley (1983b) discussed how cognitive skills that are crucial to everyday situations may not be assessed by evaluation tasks such as paired associate learning of words. In addition, the authors stated the need to consider environment and lifestyle. When attempting to assess memory deficits in everyday life, the clinician “should not rely solely on the patient’s performance on memory tests borrowed from the psychological laboratory” (p. 191). The authors suggest attempting tests that closely resemble everyday activities, such as remembering to take pills or route finding. They caution that there is a limited range of these simulated everyday tasks and it may be unclear whether the individuals’ performance is a true reflection of their behavior in normal life.

**Spontaneous Strategy Use**

Furthermore, it is often highly beneficial to observe whether or not an individual uses spontaneous strategies during testing and, if so, whether or not the strategies are effective. Harris (1996) recommended evaluating rehearsal processes, or more specifically, determining the presence or absence of rehearsal, type of rehearsal (i.e., simple or complex), and potential benefit of combining strategies (simple paired with more complex). The author concluded that “inefficient use of rehearsal strategies seemed to be a factor in severe CHI children’s poorer recall performance” (p. 88). If a patient is not observed to spontaneously use rehearsal to assist recall, the strategy can be taught in therapy. If a patient does spontaneously implement strategies during testing but is still impaired, strategies may be refined during intervention to maximize their effectiveness.

**INTERVENTIONS**

Following the identification of specific memory impairments through a comprehensive assessment procedure, specific therapeutic interventions are then initiated and prioritized based on which methods will maximize daily functioning and allow the individual maximum independence. There are two general categories of intervention for memory impairments: external memory aids and internal strategies. External aids may be thought of as visual reminders; internal strategies may be conceptualized as mental processes or cues that exist within the individual.

**External Aids**

External compensatory memory aids are implemented to assist in the storage and retrieval of information. These interventions range from very simple to extremely sophisticated. Examples include posted checklists and notes, memory notebooks, electronic organizers, electronic watches, paging systems, and computer-based systems. In addition, they can be designed and programmed to cue the individual through auditory and/or visual signals (e.g., a wristwatch with both an alarm and a light that notify the individual when medication should be taken). An overall benefit of these systems is that they may be very personally designed to meet the individual’s needs in various situations.

*Memory books.* Some of the most widely used external memory aids are memory books that have been developed with the goal of teaching compensatory strategies for specific everyday problems that arise from memory impairments (Franzen & Haut, 1991). They provide the daily structure and organization from which many CHI patients benefit. One suggestion for presenting these interventions to patients is to discuss how most professionals, students, and average (i.e., noninjured) people use daytimers to organize their lives and take the burden off their own memories. Once introduced, individuals may be taught to categorize and group incoming information into small, concise, manageable pieces, such as phone calls to be made. This information may then be organized and incorporated into the memory or schedule book and/or the appropriate external memory aid(s).

*Environmental cues.* Implementing cues in the individual’s environment may have an effective and
functional impact. Stoler and Hill stated that, following mild TBI, STM is “the most susceptible to interference from the pain, stress, fatigue, attention problems, and sensory overload” (1998, pp. 151–152). These authors recommended placing clocks and calendars in visible places, color coding objects or lists by category or event (e.g., each week being a specific color), placing lists on the front door as reminders of things to do before leaving the house, and deciding on proper and consistent places to keep things such as keys or glasses. They also provide suggestions that engage the senses of olfaction and touch (tactile stimulation), which may play roles in memory. Evidence for this may exist in the olfactory sense, which transmits sensory information directly to the primitive cortex of the medial temporal lobe (Kandel, Schwartz, & Jessell, 1991). Stoler and Hill also suggest placing different scents on different objects to be remembered and/or covering objects in certain textures or fabrics.

**Importance of training.** It must be noted that without adequate training of the external aids, intervention will not be successful. Specifically, the training of these interventions involves both behavioral learning principles (Dougherty & Radomski, 1987; Sohliberg & Mateer, 1989a) and educational strategies for individual instruction (Callahan & Clark, 1982). The four stages of treatment that should be addressed are

- **Anticipation:** identifying memory weaknesses and the need for an external aid
- **Acquisition:** learning the names and purposes of notebook sections and establishing an overlearned routine
- **Application:** learning and practicing appropriate procedures for recording information through homework and role plays
- **Adaption:** encouraging skill use in novel settings

Within each stage, didactic lessons and home practice assignments are presented. Individuals learn to (a) use the notebook sections that may include daily log, calendar, names, current work, and/or personal notes; (b) identify components of written and oral information; and (c) take comprehensible notes.

In other words, general goals for training of the systems include developing consistent recall of the sections and purposes, consistently making written records, accurately monitoring them, explaining them to family and friends, and implementing them in various settings.

Furthermore, specific training challenges may exist with the individual who has STM and WM impairments; Learning the systems may prove challenging due to the memory impairments themselves. As Mateer, Kerns, and Eso stated, “Learning may be further compromised by the difficulties with initiation, abstraction, and problem solving often seen following traumatic brain injury” (1996, p. 626). However, the decision to implement external aids is usually appropriate for clients with severely compromised memory. This is due to the concept of external aids as lessening the burden on the client’s internal mental functions by placing devices that are easily seen and heard and do not rely on the memory processes themselves.

### Internal Strategies

**Rehearsal.** Rehearsal involves repeating information that one is attempting to recall. It has been described as an important process involved in learning and memory (Harris, 1996). An example would be repeating a 7-digit phone number. The current author’s method includes having an individual repeat such numbers seven or more times and then assessing immediate and delayed recalls following the rehearsal. Informally, patients have been generally successful with this strategy (i.e., have been able to recall unfamiliar phone numbers across days and weeks).

In other words, rehearsal serves to maintain information in STM and assists with the transfer of information into LTM. Baddeley (1986) described the idea that information that is not reactivated in WM through rehearsal is lost, either in full or in part. Kupfermann (1991) discussed the idea that repetition promotes the transformation of information into more automatic or reflexive acts (i.e., declarative memory into reflexive memory or conscious into automatic).

Rehearsal can be either overt (verbal) or covert (silent) and ranges from simple (repeating a single word: “horse, horse, horse”) to more complex (rehearsing different words: “horse, lamb, cow”), to more elaborate (the “horse” is next to the “lamb”). Elaboration occurs when information is added to the items to be remembered in an attempt to connect them to one another.

Overall, Harris recommends teaching a few strategies at a time and encouraging individuals to “think out loud” (1996, p. 90). On the basis of observations of control subjects, after improving self-monitoring skills (see “Meta-memory”), individuals with memory impairments may be taught to rehearse only items that were forgotten on previous trials (though this requires recall of what items were missed), use self-correction, keep track of the number of items presented, and/or rehearse minimally toward the end of lists.

**Mnemonic devices.** Another internal strategy for improving memory is the use of mnemonics, or the mental exercises of creating memorable sayings, phrases, rhymes, sentences, or stories out of the initial consonants of words or information to be recalled (e.g., from a list). An example would be “Oh, Oh, Oh, To Try And Find Very Good Velvet AndHide,” for the twelve Cranial Nerves (Olfactory, Optic, Oculomotor, Trochlear, Trigeminal, Abducens, Facial, Vestibulocochlear, Glossopharyngeal, Vagus, Accessory, Hypoglossal). Stoler and Hill (1998) suggest using initial consonants, in addition to silly stories, songs, or acronyms (“OJ” for orange juice), as may be found in advertisements. These strategies may be especially helpful for students.
Association and imagery. The internal strategies of association and imagery involve assigning the information to be recalled to other information, such as a mental image, another word, or a sentence. In addition, there may be frequent overlap of these strategies. An example would be in attempting to recall the unrelated words “happy,” “shoe,” and “round,” one could create a sentence using the three words, such as “The happy clown wore a big shoe and had a round nose.” This may also be an example of using elaborative rehearsal, or visual imagery (i.e., “seeing” the clown in one’s mind to recall the information). Overall then, visual elaboration/imagery uses mental images or pictures that are created to assist in organization and recall of information. Following are descriptions from authors who provide specific intervention approaches for association and imagery.

Brookshire used “verbal chaining strategies,” in which individuals were “taught to arrange lists of to-be-remembered items into sentences or short stories to facilitate subsequent recall of the items” (1997, p. 379). He also discussed using mental images to organize words into a visual scene. For instance, to remember the words “fork,” “cold,” and “green,” the individual may be instructed to visualize eating a cold, green vegetable with a fork. This is also an association strategy in which the items are associated or conceptualized together. The patient may also be taught to visualize items to be recalled where they are usually kept (e.g., glasses on the bedside table), during which he or she “mentally ‘looks’ for it in the imagined scene” (p. 379).

Stoler and Hill (1998) suggested closing one’s eyes after setting items down and picturing in your mind where you placed them. They also recommend touching the area, smelling the area, and/or saying it aloud. Visualizing details of destinations and how to get to them before leaving the home may also help.

Providing further visual elaboration and imagery techniques, Lorayen and Lucas (1974) discussed the technique of “face-name association,” in which individuals are encouraged to remember details of the person whose name is to be remembered (e.g., a person whose name is Abraham and happens to have a beard may be visually and verbally associated with the past president Lincoln). Individuals progress with these lists, they may be required to recite the items in reverse order, thus exercising WM.

Picture or Object Recall

Addressing visual memory, clinicians may initially present familiar pictures or personal objects, and then proceed to using unfamiliar items. The individual may first be presented with several pictures or objects, then asked to identify the targets among a group of others, beginning the memory intervention hierarchy with recognition. Matching items in a game format, as in Concentration or Memory (Stoler & Hill, 1998), can also be employed. These tasks also exercise attention and concentration.

To increase task demands then, the individual may be shown a picture or object and then instructed to describe it from memory. Clinicians may increase or decrease the number of details to be recalled. Initial verbal cues could also be provided, such as “This is something you would find in your kitchen,” when asked to recall a fork. The individual may also be simultaneously taught to verbally rehearse the details of the pictures or objects.

Prospective Tasks

Frequently, individuals who have endured CHI experience memory failures related to prospective memory. Prospective memory tasks involve remembering to perform intended activities in the future. Examples may include recalling names, asking questions or making statements, or performing certain tasks at a specified future time. Clinicians can manipulate the number of items, increase time intervals from stimulus to recall (e.g., from 1 min after presentation to asking the patient to remember to do something at the end of a 60-min session), change the recall cues from direct requests to oblique (e.g., “there was something you were supposed to remember”), and use objects first visually present to the client and then absent. An example of a simple prospective memory task might be asking the client to remember to ask when his or her next appointment is when an alarm goes off in 10 min.

Sentence Recall

For sentence recall, tasks can be auditory (i.e., heard) or visual (i.e., read) and may include having the individual answer questions about the content and/or paraphrase the information. Clinicians can increase or decrease the length of the sentence and time intervals (immediate vs. delayed) for baseline and progress data.

Paragraph Recall

Paragraph recall is toward the more difficult end of the hierarchy of memory tasks and may also be either auditory or visual (i.e., heard or read). The same tasks for sentence recall (questions, paraphrasing) may be employed. Clinicians may again increase or decrease the length, familiarity, and/or abstraction of the content. The individual can be
instructed to first immediately recall the information. Then, other tasks can be introduced between stimulus and recall, such as spelling words backwards (i.e., WM tasks) before retelling the paragraph. Again, it is important to time these delay tasks and extend them based on success.

**Computer Programs**

Computer-based memory retraining programs include drills in which individuals practice remembering letters, numbers, words, pictures, shapes, or stories. These programs may allow controlled stimulus presentation rate and exposure time with consistency and accuracy, also keeping a precise record of response times. The PSS CogReHab programs (Bracy, 1994) include memory training programs that address visual memory, functional memory, recognition, and verbal memory. The programs provide immediate scoring for baseline and future comparisons.

**Family Involvement/Other**

Additional informal therapeutic ideas include having a friend or family member show the individual pictures, put them aside, and then instruct him or her to describe them from memory. Using personal photographs may make this activity more meaningful, interesting, and enjoyable. Overall, involving and training family and/or friends, when appropriate, is valuable as they often have more time to perform memory exercises with the individual and will most likely be involved in their care long past discharge.

Providing a good overall suggestion for intervention, Stoler and Hill (1998) recommend finishing one task before beginning another, or, if not possible, to use notes as reminders of where one stopped in a task and what is needed to complete it. In addition, group treatment may also be beneficial due to enhanced range of social interaction and encouragement from others with similar challenges.

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**A SPECIFIC INTERVENTION TECHNIQUE ADDRESSING MORE SEVERE COGNITIVE DEFICITS**

Due to the potentially high cognitive demand of the aforementioned techniques, a method called “spaced retrieval” was created by Schacter, Rich, and Stampp (1985), which uses a similar task as face-name association. The main idea of the spaced retrieval technique involves learning to retrieve information at various intervals after presentation. There is no need to engage in the elaborate processing required by imagery and organizational strategies. It is based on the retrieval properties of the memory system. The method attempts to maximize the mnemonic benefits of recalling a previously studied item.

The first description of such a technique was by Landauer and Bjork (1978), in which subjects were asked to recall surnames in the presence of given names. For each name, there were three successive tests following an initial study trial; the test trials were separated by study trials concerning the other names. The critical feature was that the temporal sequencing of the three tests was systematically varied. There was a uniform condition, in which each of the three tests was separated by an equal number of intervening study trials. In the expanding condition, the three successive tests were separated by an increasingly large number of intervening study trials.

To use spaced retrieval, clinicians show a series of pictures of faces and ask the individual to remember particular characteristics associated with the faces, such as name, occupation, or hobby. Clients are instructed to remember the characteristic and recall it when shown the face 1 1/2 min later. During the delay, clients may perform letter search puzzles and/or various self-report inventories. After a 90-s filled delay, they are asked to recall the characteristic upon re-presentation of the face. Clinicians first assess during six uninstructed baseline sessions, and then introduce the spaced retrieval technique during eight training sessions. After exposure to the face-characteristic pair on each trial, the individuals are cued to retrieve the designated characteristic at three points during the 90-s delay, separated by increasingly long temporal intervals (3s, 10s, and 30s).

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**REVIEW OF TREATMENT EFFICACY**

**LITERATURE AND DISCUSSION**

Having discussed several interventions for memory impairments, the reader may wish to know the efficacy of these therapeutic methods. A literature review provides useful information when considering which methods to employ with the individual enduring STM and WM impairments secondary to CHI. In general, memory aids have been found to have limited generalization to real-life functioning and also have not generalized to improvements on standardized measures of recall (e.g., Brookshire, 1997; Mateer et al., 1996; Miller, 1992; Richardson, 1992; Robertson, 1990; Schacter et al., 1985). Some subjective reports, however, have indicated improvements in patients’ daily functioning.

Specifically, external aids do not place a large cognitive demand on clients, which may be a significant factor in deciding which method to employ with certain individuals. In other words, individuals who are severely cognitively impaired likely will not benefit from internal strategies, which have been criticized due to the cognitive demand they may place on the users. For those clients, however, who possess the cognitive abilities to effectively use internal strategies for specific tasks, they may provide benefit.

**External Aids**

Formal efficacy studies on external aids are limited, though qualitative and subjective descriptions may shed positive light on these interventions in terms of their long-term benefits. This may be especially true given the fact that external aids may be used relatively easily by individuals with significant cognitive impairments. Overall, as Mateer et al. (1996) stated, it is important to train individuals in
the use of the memory systems and to modify the systems to meet the individuals’ needs.

**Memory books and systems.** Mateer and Sohlberg (1988) discussed how determining the efficacy of memory notebooks involves measurements of accuracy and consistency that result in skill maintenance and use. The authors outlined a three-phase learning method for individualized teaching of memory books. They reported numerous successes with the notebook technique, including three individuals with amnesia who achieved independent living. There were, however, no substantial improvements in standardized laboratory measures of recall.

Later, these same authors (Sohlberg & Mateer, 1989b) discussed a young man who suffered a TBI and subsequent severe amnesia, as well as other cognitive impairments. He required 6 months of training to implement an external memory system. Ultimately, he returned to independent living and was able to work in structured settings with the system; however, he too demonstrated no improvement on standardized measures of recall.

Reporting similar qualitative, though not quantitative, benefits, Schmitter-Edgecombe, Fahy, Whelan, and Long (1995) studied 8 participants with TBI who received either a 9-week memory notebook training or supportive therapy. In testing performance, the authors used laboratory-based recall to obtain a recall score that was the average of four standard scores that were all significantly correlated \( r = .60 \). No significant difference between notebook training and supportive therapy was found for laboratory-based recall. Subjectively, however, the authors discovered that the group who had received notebook training reported fewer memory failures on a daily checklist immediately post treatment, though this finding no longer reached statistical significance 6 months later. Furthermore, there were reportedly less instances of “forgetting something that the participant was told, forgetting to pass on a message, forgetting where he or she put something, having to check whether he or she had done something, forgetting what he or she did yesterday or getting the details confused and forgetting an appointment” (p. 487). The authors spoke of the potential for this intervention to help compensate for everyday problems arising from memory impairment secondary to CHI, thus providing long-term benefits.

Providing a comment that may provide a fitting summary to external aids, Miller positively contrasted the efficacy of external strategies versus internal strategies and stated that external strategies “may well confer greater benefit and can be readily adapted to everyday circumstances” (1992, p. 5). Miller also described how external aids do not place large mental demands on the user and how the strategies require much more exploration, particularly in regard to what kinds can be best used in which circumstances. The author also addressed the ease with which modern electronic gadgets may be used.

**Internal Strategies**

**Verbal elaboration/rehearsal and visual imagery.** These strategies generally have also been criticized due to limited generalization and spontaneous use, as well as the substantial cognitive effort required to use them. Knowing how, when, and where to employ rehearsal or imagery is necessary to support effective learning in daily life and depends on the presence of other relatively intact cognitive functions (e.g., executive functioning). Following are some specific efficacy studies.

In an article describing psychological approaches to treating memory deficits, Miller stated, “Internal strategies have not proved successful, and this is partly because they place a heavy mental load on those who use them” (1992, p. 5). The author also describes this to be true for non-brain-injured individuals, let alone those who may also have other information processing limitations secondary to brain injury. Miller described internal strategies as “simply not ‘user friendly’” (p. 5). He stated that such techniques, such as imagery, see their biggest advantage in learning such things as lists of unrelated words, which is not the type of task for which individuals normally use their memories.

In order to assess the efficacy of verbal rehearsal, Harris (1996) used qualitative analyses of a free recall task to demonstrate impaired verbal recall and inefficient, passive rehearsal strategy in severely injured subjects. The author concluded that inefficient use of rehearsal strategies seemed to be a factor in the poorer recall performance of children who had sustained a severe CHI and that using rehearsal actively “may be a skill that is difficult to reacquire following injury” (p. 89).

In an article describing research regarding the management of memory and attention disorders following TBI, Mateer et al. (1996) stated that new information can be learned using strategies such as verbal rehearsal and mnemonics, but their spontaneous use and generalization are limited. The authors described how these strategies have demonstrated very limited efficacy in the literature; however, the tasks have remained popular in practice. Overall, the effects of these approaches are highly specific to the training tasks, and the problem of generalization to new contexts or materials in real-world settings is challenging.

Addressing limitations of visual imagery, Schacter et al. (1985) described how “imagery and organization require a great deal of cognitive effort to be used effectively by patients in their everyday lives” (p. 80). Thus, in attempts to avoid this cognitive demand, the authors used an aggregate of four case studies, each composed of four consecutive phases (baseline, cued training, self-cued training, and assessment), to study the spaced retrieval technique. Their results indicated that the technique may be useful “only when the amount of to-be remembered information is relatively small” (p. 93).

On a positive note, Ornstein and Naus (1978) wrote about rehearsal processes as representing “a group of processes under the subject’s control which serve both to maintain information in a temporary short-term store and to facilitate the movement of information between this short-term store and a more permanent long-term store” (p. 70). The presence of having such cognitive control and abilities appears to be the key to the effective utilization of verbal elaboration/rehearsal and visual imagery methods.

**Mnemonic training.** Mnemonic training has also been shown to have limited generalization and is also influenced
by the functioning of other cognitive areas. Schacter et al. (1985) noted that research in the use of organizational mnemonics does not provide convincing evidence that these techniques are used spontaneously, either in the laboratory or in clients’ everyday lives. “Because of the extensive cognitive resources that are required to use imagery and organizational mnemonics spontaneously, it may prove difficult to teach patients to use these techniques on their own” (p. 80).

Richardson (1992) reviewed 20 years of research regarding the history of imagery mnemonics and evaluated the claim that these techniques are useful in the treatment of memory disorders in individuals with brain damage. Overall, his statements are similar to the aforementioned descriptions of limited generalization. In his article, he stated that even for those clients who improve on testing, “there is little evidence that they maintain the use of these techniques in similar learning tasks or generalize the use to new learning situations” (p. 283). He also described how imagery mnemonics appear to be of little practical daily value in activities that are most valuable to the individuals. Furthermore, due to the mental effort required to use these internal systems, personal variables such as motivation and insight should be considered.

**Computer programs.** Consistent with some of the general critiques of memory interventions, these programs may have limited generalization and benefit to the individual’s daily functioning. As Brookshire (1997) discussed, studies evaluating computer-based memory retraining programs have little value for creating meaningful changes in the daily lives of individuals with TBI.

In his article reviewing the efficacy of computerized cognitive rehabilitation, Robertson (1990) described how there was no evidence that computerized memory therapy was effective. The author also discussed how computer cognitive rehabilitation procedures had not been shown to generalize to real life, though he mentioned some positive results of attentional computer training, which may have positive implications as one may conceptualize attention as the basis of memory and other cognitive functions.

**Meta-memory.** Overall, it is appropriate to consider the individual’s perception of their own memory. Schmitter-Edgecombe and Woo (2004) discussed the importance of meta-memory in the efficacy of strategy use to improve memory performance. Meta-memory involves the processes involved in the conscious monitoring and control of one’s own memory functioning; in other words, knowing one’s memory. The authors conclude that “given the central role of memory in everyday activities, developing a better understanding of meta-memory functioning in CHI has important practical implications” (p. 1014). They suggest that it may be possible to build upon meta-memory skills to help individuals use strategies more consistently.

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**PRIORITIZED IDEAS FOR FUTURE RESEARCH**

The need for further research in these areas is apparent. One of the most crucial research questions may involve which methods most effectively lead to generalization and evaluation of effective practical use of memory interventions during real-world activities. In other words, there is a need to analyze the effectiveness of certain training techniques over others, specifically in relation to attaining practical goals. Which techniques are more effective in actually persuading individuals to implement the memory interventions in their daily life? How much influence do clients’ personalities and interests play into the equation? Is it the clinicians’ specific approaches and enthusiasm to training the devices that influences whether or not an individual actually uses the devices outside of the therapy rooms? How effective are group training sessions; in other words, are individuals positively influenced by witnessing others use the interventions?

Future studies regarding personal characteristics may also be helpful in determining the efficacy of memory remediation efforts. As Prigatano et al. (1984) discussed, “Cognitive and personality disturbances following severe closed head injury in young adults are associated with poor rehabilitation outcome” (p. 505). To what extent do additional cognitive impairments (e.g., attention and executive functioning deficits) negatively affect the actual implementation of the memory interventions in day-to-day functioning outside of the hospital and therapeutic settings? Techniques for identifying and working with individual personality variables, while simultaneously remediating memory deficits, may also significantly promote the efficacy of memory interventions.

Finally, the best judge of the value and efficacy of our services usually is the client. Ultimately, it would be useful to determine whether or not self-rating scales, interviews, and daily checklists are better outcome measures of memory remediation than standard neuropsychological tests (i.e., subjective vs. standardized). Especially in the case of memory, a cognitive function that is impacted and influenced by numerous personal factors, would subjective measures indicate more functional gains than impersonal, standardized scores? Future research may need to address the most effective ways to obtain information from the individuals themselves. However, for those individuals who are able to self-monitor their performance, self-questionnaires or journals may be complicated by variables such as age, sex, emotional status, and attitudes about the nature of memory skills. In addition, if the clients are rated by significant others, factors such as personal bias or pity may impact the accuracy of observations, as objectivity may not be present.

Therefore, if individuals were given checklists to record if they are completing important daily tasks, instead of rating themselves on how they are doing, that may provide an objective means of recording success. For instance, recording percentages of daily tasks that individuals recall and complete, as well as which methods are used to recall them, may provide an objective measure of efficacy. We may thus benefit from further research aimed at verifying the usefulness of daily checklist measures for documenting daily improvements following treatment. Similarly, Schmitter-Edgecombe et al. (1995) stated, “The development of laboratory procedures that better assess EMFs
(Everyday Memory Failures) by simulating situations that lead to common memory failures should also continue to be a goal for future research” (p. 489). These procedures may serve to eliminate subjective errors when using self- and/or observer reports to evaluate treatment efficacy.

Overall, as specific interventions are increasingly shown to be effective, they will be increasingly used. Subsequently, limitations on the daily functioning of individuals who are enduring STM and WM impairments following CHI will decrease, as their quality of life is enhanced and improved from our interventions. What makes our work difficult to measure is the fact that clients are unique individuals doing extremely varied and unique things every day, and it is difficult to fully account for events for which we are not present. It is the rare clinician who can be with a patient 24 hr per day to evaluate how his or her interventions are working. Thus, it appears that an overall priority for future research is the need to investigate how to best obtain the clients’ own reports and demonstrations of the efficacy of our interventions in their lives.

CONCLUSION

The complexity of impaired memory processes is phenom-
ena.l. Assessment and intervention planning must consider the individual and his or her specific daily tasks, which poses further challenges to the clinician who is usually unfamiliar with his or her client. Numerous factors influence successful intervention, and it is the keen and practiced clinician who achieves functional and meaningful improvements. Limitations, as well as successes, are found in the literature regarding various interventions currently in practice, due in part to the complexity and individuality involved. There is, without doubt, an intense need for further research in the area of memory impairments following CHI in order to enlighten practitioners to the pros and cons of their past, current, and future treatment procedures, thus enabling them to provide further benefit to their patients. Designing interventions that will transition out of the therapy room and make the most meaningful impact on the daily functioning of the individual should be our ultimate goal.

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REFERENCES


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