Supervisor: Dr. Catherine Mateer

ABSTRACT

In the current study, I investigated the question of whether there is a specific effect for the administration of attention retraining above and beyond a supportive, adjustment-oriented approach in improving attentional functioning in individuals with traumatic brain injuries (TBI). Neuropsychological, neurophysiological (event-related potentials), and self-report measures were collected for five participants in a single case modified multiple baseline cross-over design. Each participant underwent a six week baseline phase, six weeks participation in Attention Process Training (APT) and six weeks participation in an Active Control condition. Dependent measures were collected at two week intervals throughout the study. Data were analyzed using graphing and visual inspection. Results indicate that attention retraining produces the most change on neuropsychological and event-related potential measures, as compared to an adjustment-focused therapeutic approach. Event-related potentials were found to be the most sensitive measure, with all participants demonstrating change in either latency or amplitude of the P300 or N200 evoked potential. These findings support the continued use of attention retraining as a valuable rehabilitative tool. Neurophysiological data support the hypothesis that underlying neuronal change may occur as a result of participation in attention retraining. Only two participants demonstrated change on a measure of self-efficacy and it was not possible to discern the individual contribution of each therapeutic condition. Two participants demonstrated change on daily ratings of attention problems. For one participant, this coincided with participation in APT; for the other it occurred during

participation in the Active Control condition. This suggests that patient characteristics and treatment interactions are an important avenue of future study.

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TABLE OF CONTENTS

List of Tables

List of Figures

Acknowledgements

I would like to express my appreciation to my committee members for their time and effort in helping me to complete this project. I would like to thank my supervisor, Dr. Catherine Mateer, for her guidance and support of my academic and clinical work. I would also like to extend a special thank you to my research assistant, Kent Kodalen, for his effort on this project above and beyond the call of duty. Finally, I would like to acknowledge the Natural Science and Engineering Research Council (NSERC) and the Sara Spencer Foundation for support of this study.

On a personal note, I would like to thank my parents, David and Barbara Penkman, whose unwavering support and belief in me has always been my foundation. As this project is completed and my time at the University of Victoria draws to a close, I would also like to thank those people who shared the struggles of graduate school with me and who were always there with an ear, a shoulder, or a smile: Shannon Johnson, Tavi Nicholson, Harpreet Aulakh, Andrew Blackett and Jeff Compton. Finally, I would like to thank George Beatteay for his love and support.

INTRODUCTION

Traumatic brain injury (TBI) affects approximately 50 000 people each year in Canada; in British Columbia alone, 4500 people per year sustain brain injuries from traumatic causes (Vancouver Island Head Injury Society). Due to advances in medical technology, people are surviving serious accidents that compromise central nervous system functioning. Many of these survivors are left with a host of physical, cognitive and emotional problems that leave them unable to return to their premorbid level of occupational, educational and/or social functioning. Neuropsychologists have played an important role in the understanding of TBI and are frequently called upon in a court of law to explain the devastating effects of this often invisible disabling condition. Despite sophisticated neuropsychological assessment techniques, neuropsychological rehabilitation of brain injury is in its infancy.

Due to the financial, time, and emotional investments made by individuals with TBI and their family members when participating in a rehabilitation program, it is the responsibility of the professional rehabilitation community to strive to learn as much as possible about how rehabilitation of cognitive functioning works, what are the crucial elements, and who is best helped by it. Increased knowledge about TBI and neuropsychological rehabilitation will help professionals to better direct and advise their clients. It will also assist in the planning of cost and time effective treatment programs that provide maximum benefit to clients.

Pathophysiology of Traumatic Brain Injury

When a brain injury is acquired, neurological damage occurs due to the primary and secondary effects of the injury. There are two main types of traumatic brain injury pathophysiology.[1] The most common neurological effect of TBI is diffuse axonal injury (DAI) (Pearl, 1998). It occurs when a rotational force is applied to the head when there is a velocity differential between the head and the body; the force is transferred to the head via the neck. This results in the brain moving about in the skull and axons are stretched and torn. This type of injury is typical of acceleration-deceleration injuries such as motor vehicle accidents (MVAs). Microscopic lesions not visible on CT scan are associated with DAI. Magnetic resonance imaging (MRI) appears to be more sensitive in detecting damage due to DAI (Levin, Williams, Eisenberg, High & Guinto, 1992). The shearing lesions associated with DAI tend to be concentrated in the frontal and temporal lobes, interfaces between the gray and white matter around the basal ganglia, periventricular zones, body and splenium of corpus callosum, and dorsolateral aspect of the brain stem and the cerebellum (Parizel, et al., 1998). At a microscopic level, the damage associated with DAI takes the form of stretching and tearing of axons. When axons are severed from their cell body Wallerian (anterograde) degeneration takes place and they die. In some cases retrograde degeneration will also occur, resulting in the death of the cell body itself. Transneuronal degeneration may also occur when more distal cells lose their innervation from the damaged axon.

Contusions or more focal injuries are also noted following TBI. They are the result of the brain impacting on the rigid internal surface of the skull. The most frequent

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[1] This discussion is limited to traumatic brain injury due to closed head injury.

sites of contusions following TBI are the orbital regions of the frontal lobes and the poles of the temporal lobes (Auerbach, 1988). They are differentially vulnerable due to their proximity to the rough bony surfaces of the anterior cranial fossa and the spheniod wings. In fact, MRI has confirmed that the frontal region is the most common location of focal lesions after mild to moderate TBI (Levin & Kraus, 1994). Similarly, a study using positron emission tomography (PET) revealed neuropathology to be pronounced in the frontal and anteriotemporo-frontal regions in mild TBI (Ruff et al., 1994).

Secondary effects of TBI include intracranial hematomas which can occur when blood vessels are torn on impact. Edema (brain swelling) may occur due to hyperemia (increase in cerebral blood volume), or due to increased volume of intra- or extra-cellular fluid in the brain tissue. Swelling of brain tissue may affect brain structures distant from the site of impact due to the pressure of mass effects (i.e., the brain shifting its position within the skull and compressing structures). Raised intracranial pressure (ICP) is a dangerous complication of the above mentioned secondary effects of TBI. Hypoxia (decreased supply of oxygen to the brain) and raised ICP can lead to cerebral ischemia. The decreased blood supply and oxygen deprivation result in the breakdown of important metabolic processes of neurons such as the removal of lactic acid. This results in a condition known as acidosis which alters the excitability of neural tissue and results in autoneurotoxicity; the neuron is over-excited resulting in cell death.

Recovery of Function

Recovery after TBI is generally the most rapid in the first three to six months post-injury but may continue at a much slower rate for several years (Thomsen, 1984 cited in Ponsford, 1995). Recovery in the acute stage is largely attributable to diaschisis, a temporary loss of function in an adjunct region or in a region connected to the damaged area via fibre tracts. Resolution of diaschisis refers to the reinstatement of functions that were temporarily disabled by secondary effects of the brain injury such as edema. These have been referred to as "shock" effects (Sohlberg & Mateer, 1989); the neurologic system is not permanently damaged.

Beyond diaschisis, the mechanisms underlying recovery of function following brain injury are relatively poorly understood. This is largely because most of the theorized changes occur at a microscopic level and we do not possess the technology to investigate these processes in living human beings. The concept of plasticity is thought to underlie recovery of function. Plasticity is the brain's capacity for continuously changing its structure, and ultimately its function throughout a lifetime (Kolb, 1995). This may occur as a result of learning, development, environmental stimulation, or adaptation after an injury to the brain. Current theories of plasticity suggest that recovery may be the result of restitution of function to damaged areas due to axonal regrowth or sprouting of new nerve fibres, or increased dendritic branching. Denervation supersensitivity may also play a role in restitution of function. This occurs when a neuron loses some of its input and there is a proliferation of receptors so that hypersensitivity occurs; this results in a greater effect from lesser neurotransmitter input. Other theories suggest that recovery occurs through reorganization or substitution. It has been suggested that there is a certain amount of redundancy in the brain and that there are pre-existing "silent synapses" that can subserve a particular function but are normally inhibited. When an inhibitory system is damaged, the silent system comes on line and subserves the function (Meier et al., 1987, cited in Solhberg and Mateer, 1989).

Some of the mechanisms of plastic change within the CNS have been demonstrated in animals (e.g., Kolb, 1995). Kolb (1999) cites numerous examples of enhanced dendritic arborization in rats following lesions to the cortex. Research with rats has suggested that rearing in an enriched environment results in cortical changes such as changes in dendritic length and number of synapses per neuron (Hebb, 1947; Wallace, Kilman, Withers & Greenough, 1992; Kolb, Gorny & Gibb, 1995, cited in Kolb, 1995; Kolb, 1999). Rutledge and colleagues (1978) demonstrated that cats with lesions that deafferented the neocortex demonstrated a decrease of dendritic and axonal branches and a loss of synapses. However, electrical stimulation of the neocortex of the cats resulted in significant reinnervaton of pyramidal cells. This research suggests that neocortical plasticity does occur and that it is modifiable by neocortical activity which is influenced by behavior. Human autopsy evidence from two individuals who died after sustaining bilateral uncal herniation and basal ganglia hemorrhage showed an intensification of Acetylcholinesterase (AChE) staining in the entorhinal cortex of the hippocampus, implicating sprouting of cholinergic fibres (Grady, Jane & Steward, 1989). This study provides concrete evidence that reactive syntapogensis (the creation of new synapses in response to injury) also occurs in the human nervous system. The rationale of the remediation or direct retraining approach to neuropsychological rehabilitation is based on the hypothesis that neuronal growth is associated with the simple exercise of neuronal circuits (Benedict, 1989). Similarly, the process oriented approach to neuropsychological rehabilitation (Sohlberg & Mateer, 1989) rests on the assumption that a cognitive function, such as attention, can be improved through targeted practice which may be causing underlying cortical reorganization and the growth of new pathways to support function.

Recovery of, or improvement in, function may also occur due to functional adaptation. That is, an individual with TBI learns new ways to perform a task. Instead of relying solely on his memory to get to appointments, a person with brain injury may use a day-timer and an alarm system. Similarly, a person who suffers from unilateral spatial neglect may learn to pull a piece of paper across the table so that the entire item comes into view. Most approaches to neuropsychological rehabilitation rely in part on some type of behavioral compensation.

Non-Organic Factors Involved in Recovery of Function

A discussion of recovery of function after brain injury in human beings would not be complete without some consideration of the complexity of the social and emotional consequences of TBI and the effect that these factors may exert on the recovery process. As Macniven and Finlayson (1993) assert "the relationship between cognitive functioning and emotional status after head injury is complicated." They also advise considering the interaction of these variables in predicting recovery. Individuals with TBI are often faced with profound changes in their daily lives, relationships and abilities. It is not surprising to find that one of the sequellae of TBI is emotional distress. This is an often overlooked characteristic of this population. Mateer and Raskin (1996) note that fear, frustration and feelings of loss are common responses on the part of the brain injured person and their family. Moore and Stambrook (1995) state that "how a person explains what has happened to them, why, and to what extent it has changed his or her life situation, and how it will affect the future are powerful determinants of present and ultimate recovery, as it affects choice of coping strategies and motivation." They go on to state that TBI patients are at risk for developing self-limiting cognitive belief systems as they attempt to account for the changes in their lives. They present a model of these belief systems that includes an external locus of control, a helpless/hopeless cognitive style and poor coping strategies. Mateer and Raskin (1996) note that the importance of providing assistance in dealing with the emotional responses to these changes in functioning cannot be underestimated. Neuropsychological rehabilitation may assist TBI patients in gaining a sense of control over some of their difficulties and may enhance their sense of self-efficacy.

Self-efficacy was first discussed by Bandura (1977) and is defined as one's beliefs about one's ability to perform a certain task or skill. Bandura's theory states that beliefs about personal efficacy will determine how long one will persevere at a task and whether coping behaviors will be instituted. Bandura states that self-efficacy beliefs are derived from four main sources of information: personal performance accomplishments, vicarious experience, verbal persuasion and physiological states. As originally conceived by Bandura, self-efficacy was considered to be task specific. That is, a person may hold different self-efficacy beliefs about different tasks. Bandura also discussed the idea that specific task efficacies might be "domain-linked." Woodruff and Cashman (1993) have referred to this as domain efficacy; an individual's self-efficacy in a new situation may be based on experiences in other *similar* situations. Others have discussed self efficacy as being a more general construct that is influenced by experiences in a variety of situations (Sherer, Maddux, Mercandante, Prentic-Dunn, Jacobs, & Rogers, 1982).

Explanations of increased self-efficacy have been offered to account for change in therapeutic interventions with psychological disorders such as phobias. Like treatments for phobias (e.g., systematic desensitization), neuropsychological rehabilitation offers the requisite conditions for changes in self-efficacy to occur as outlined by Bandura's theory. Personal performance accomplishments definitely occur in a rehabilitation setting when a client experiences success on a difficult task. Vicarious experience is also available in many rehabilitation settings; in group settings, clients observe others tackling difficult tasks. Bandura outlined several characteristics of models in order for vicarious experience to have its most powerful effect on self-efficacy; he stated that determined effort (a coping approach) as opposed to an effortless execution of the task (a mastery approach) is more effective, as is perceived similarity to the model. These characteristics of vicarious experience appear to be amply met in most rehabilitation settings where clients observe other individuals with TBI struggling to master difficult tasks. Verbal persuasion may also be present in a rehabilitation setting, particularly when the treatment is therapist-delivered or moderated. Finally, physiological arousal may be reduced in a rehabilitation setting in much the same way as it is in a treatment for phobias. When a person is repeatedly exposed to tasks that are difficult and anxiety provoking, the level of arousal may eventually decrease providing clients with physiological signals that they are less anxious.

Self-efficacy as a moderator variable has been examined in a number of populations such as people trying to quit smoking (DiClemente, Prochaska, & Gibertini, 1985), individuals with alcohol dependency (Lee & Oei, 1993), individuals with eating disorders (Wilson, Rossiter, Kleifield & Lindholm, 1986), and individuals with chronic pain (Kores, Murphy, Rosenthal & Elias, 1990). A recent review of the literature revealed that self-efficacy has not been systematically examined in a brain injured population although it has been considered as a possible important factor by some authors (Mateer and Raskin, 1996; Moore & Stambrook, 1995). Ben-Yishay and Diller (1993) recognize the potential import of self-efficacy in rehabilitation and state that it merits "serious consideration in neuropsychological rehabilitation of brain-injured individuals." Self-efficacy has been examined as a variable in a study examining empowerment for families with a head injured member (Man, 1999). As discussed above, changes in self-efficacy may play some role in recovery of function after brain injury.

Finally, the issue of awareness deserves a brief mention. Lack of insight or awareness, either of one's deficits or one's behavior, is not uncommon after TBI. It is included in this section entitled "non-organic factors" with the caveat that unawareness after brain injury may be organically based or psychologically motivated, or some combination of both. In the field of neuropsychological rehabilitation, awareness refers to the ability of a client to possess knowledge of his or her deficits and to understand the implications of these deficits (Sohlberg, 1996). The conventional wisdom among rehabilitation therapists is that awareness is very important to rehabilitation outcome (Mateer, 1998, unpublished data). An individual who is unaware of their impairment is unlikely to comply with a rehabilitation program (Fleming, Strong & Ashton, 1996). Studies addressing this issue provide support both for and against this premise (Herbert & Powell, 1989; Prigatano, 1996). Rehabilitation strategies designed to specifically target awareness deficits may be implemented such as didactic educational approaches, supported failures or video taping of behaviors. In some cases, strategies used as part of the direct retraining portion of the rehabilitation procedure, such as charting performance and verbal feedback, may serve to increase awareness. The role of awareness in recovery of function after TBI has not been sufficiently explored as of yet.

Attentional Deficits after Traumatic Brain Injury

Attentional deficits are a very common complaint following TBI; concentration problems, together with poor memory, are reported to be among the most common postconcussional symptoms (Binder, 1986). The preponderance of attention dysfunction after TBI is due to several factors. Firstly, the widespread disruption of axonal fibres seen in DAI results in impaired cognitive efficiency, reduced mental speed and impaired attention (Putnam, Millis & Adams, 1996). Trexler and Zappala (1988) suggest that diffuse brain damage is likely to interrupt or disconnect the attention system; this is likely because it is dependent on a distributed neural system requiring efficient neural communication. Some have argued that slowed processing speed is the primary deficit after TBI (Van Zomeren, Brouwer and Deelman, 1984; Ponsford & Kinsella, 1992). Slowed information processing speed reduces information processing capacity (Ponsford & Kinsella, 1988), presenting clinically as attentional deficits. Others report deficits in focused, divided, selective and sustained attention after TBI as well as deficits in the control and allocation of attention (Niemann, Ruff & Kramer, 1996; Stuss, Stethem, Hugenholtz, Picton, Pivik, & Richard, 1989)

Second, contusions are also noted following TBI, most commonly in the frontal and temporal areas. The frontal lobes are believed to be critically involved in the control and modulation of attention (Stuss, Shallice, Alexander & Picton, 1995). Therefore, damage to this area could result in impaired control of attention. The frontal lobes, particularly the prefrontal area, have reciprocal connections with the ascending reticular activating system (ARAS), and the posterior parietal lobes, both important in attentional function.

The ARAS, in Luria's terminology, is known as the first functional unit (Luria, 1973). It is implicated in the maintenance of arousal and general "cortical tone." Since the famous studies of Moruzzi and Magoun (1949, cited in Bourne, Dominowski, Loftus, & Healy, 1986), the reticular formation of the brainstem has been well established as essential to the maintenance of consciousness and the regulation of arousal. The locus coreuleus is located in the reticular formation. It is the most important source of norepinephrine (NE) to the brain. NE is implicated in attentional function. Its innervation is strongest in the posterior parietal lobe, pulvinar, and superior colliculus, all structures believed to be critically involved in spatial attention (Posner & Petersen, 1990). It is believed to exert its function by inhibiting spontaneous discharge of neurons, thereby increasing the signal to noise ratio.

Posner and Petersen (1990) conceive of attention as being subserved by a system of neural networks that are anatomically separate from data processing systems but act upon them to modulate which environmental stimuli receive attention. The posterior attentional system consists of the pulvinar nucleus of the thalamus, the superior colliculus of the midbrain and the posterior parietal lobe. This system disengages attention, shifts attention to a new location and re-engages attention at a new focus. The frontal lobes are believed to modulate this process through their connections with the posterior parietal area.

Recently, several authors have suggested that interference control and inhibition may be located prefrontally. Specifically, some have speculated that interference control may be an orbital function and that inhibition is mediated by dorsolateral prefrontal cortex (Fuster, 1989; West, 1996). However, this proposal is purely speculative. The location of these functions to frontal structures is however, parsimonious with the common clinical observation of excess distractibility in patients with traumatic brain injury involving frontal regions.

A third neuropathological explanation for attention dysfunction following TBI has been offered by Arciniegas and colleagues (1999). These authors suggest that clinically manifested attention problems in TBI patients are due to impaired sensory gating. The hippocampus (HC) is involved in receiving and relaying information and is the putative site (the CA1 region) of the formation of short-term memories. Acetylcholine (ACh) plays a critical role in these functions. They purport that TBI may disrupt normal functioning of the HC and its cholinergic connections via DAI or through direct trauma to the medial temporal region. As noted earlier, the temporal lobes are particularly vulnerable to contusions following TBI due to proximity to bony protuberances on the skull surface. Damage to cholinergic neurons results in decreased availability of ACh manifested clinically as inattention and memory impairments.

As alluded to above, attention is no longer thought of as a unidimensional concept. Sohlberg and Mateer (1987) define attention as "a multidimensional cognitive capacity which directly impacts new learning, memory, communication, problem solving, perception and all other domains of cognition." They have developed a clinical componential model of attention to attempt to capture the diversity of attentional functioning. Their model is hierarchical in nature. Focused attention is the ability to respond to a specific sensory stimulus. This type of attention is evident when a person emerges from a coma and can respond to a painful pin prick or to their name. Sustained attention is the ability to maintain a behavioural response for a period of time during continuous and repetitive activity. Selective attention is the selection of a particular stimulus in the presence of competing or distracting stimuli. A person is demonstrating selective attention when they are listening to someone speak in the presence of background noise such as in a noisy cafeteria. Alternating attention is switching between different tasks requiring different cognitive and behavioral demands. The highest level of their hierarchy of attentional components is divided attention which they define as the division of attentional resources between two or more tasks simultaneously. Performance typically decreases with task complexity.

Others have partitioned attention differently. For example, Mirsky, Anthony, Duncan, Ahearn & Kellam (1991) conducted a factor analysis of putative attention measures and obtained four attention factors: focus and execute, sustain, shift and encode. Posner and Petersen (1990) define the three main functions of attention as: orienting, signal detection, and vigilance. For the purpose of this study, attentional components will be discussed as outlined by Sohlberg and Mateer. Their model has proved to be clinically useful because neuropsychological tests are available to assess each attentional component. In addition, a rehabilitation strategy has been developed based on this model. This strategy will be discussed in more detail at a later point in this paper.

Before concluding my discussion of the theoretical basis of attention, I would like to refer briefly to the concept of "working memory." In general terms, working memory is described by neuropsychologists as the active maintenance of information in mind in order to work with it. As such, it is intimately related to attention and deserves mention. The best described model of working memory at the present time is that of Baddeley (1990). He conceives of a Central Executive which co-ordinates or controls two working memory or attentional systems. These "slave" systems are termed by Baddeley the phonological loop and the visual spatial scratchpad. Each is responsible for on-line holding of modality specific information (auditory verbal and visual). This system can be thought of as an attentional system which bridges executive functions and memory.

Rehabilitation of Attention

Several authors have written about the difficulties that clients with attention dysfunction experience when trying to return to their premorbid level of functioning (Ponsford, Sloan & Snow, 1995; Sohlberg & Mateer, 1989). Common complaints include not being able to do more than one thing at a time or having difficulty concentrating in the presence of background noise. It has been posited that attention dysfunction is an underlying factor in many apparent failures of memory and contributes substantially to difficulty with reintegration into independent living and vocational settings (Sohlberg & Mateer, 1989). Brooks and McKinlay (1987) reported that attentional impairment predicts return to work after head injury.

A positive challenge for professionals working with clients with attention dysfunction is that it appears to be amenable to treatment. Treatment typically involves having clients engage in a series of repetitive drills or exercises. The tasks are usually arranged hierarchically, placing increasingly more and more demands on the attention system. The rehabilitation of attention dysfunction is a rapidly growing area with some empirical evidence supporting its efficacy (Solhberg & Mateer, 1987; Neimann, Ruff & Baser, 1990; Gray & Robertson, 1989; Gray, Robertson, Pentland & Anderson, 1992; Sturm, Willmes, Orgass & Hartje, 1997).

Research investigating the efficacy of attention rehabilitation has been carried out in diverse ways by different researchers. Both single-case designs and group formats have been used. Many of the early researchers targeted attention as a general entity, whereas recently, authors have begun to investigate the individual response of the different components of attention to rehabilitation (Sturm, Willmes, Orgass & Hartje, 1997). Some of the literature evaluates attention retraining as administered by a computer and others have evaluated a program delivered by a therapist doing intensive one on one work. Those studies evaluating a computerized rehabilitation program will be considered first.

Ethier, Baribeau and Braun (1989) administered a wide range of computerized tasks involving attentional, visuospatial, mnemonic, auditory, verbal and non-verbal problem solving functions to 22 individuals with TBI. The participants spent two hours per week (two one hour sessions) for six months working on the computerized tasks. They received neuropsychological assessments at pre and post-test. The authors report a large effect for change on most of the cognitive tasks (94% showed improvement). In fact, the average improvement was a z score of 2.1. Although these results appear impressive, the dependent variables in this study were the tasks that the participants were practising twice weekly. This seriously weakens these results, suggesting that the participants may simply have improved due to practice. There is a concern presented in the rehabilitation literature that improvement on tasks does not necessarily generalize to daily life. Ethier and colleagues did not report the neuropsychological test scores so they have not even demonstrated generalization to a different set of tasks, let alone a daily life activity.

Niemann, Ruff and Baser (1990) investigated the efficacy of attention training by randomly assigning 26 moderate to severely injured individuals with TBI to either an attention training group or a memory training group that served as a control. Training was structured into visual, auditory and divided attention tasks, all delivered by computer. Participants in the memory training condition received training in using internal memory aids, such as visual imagery, and external memory aids such as diaries and checklists. Their results indicated that the attention group improved significantly more than the memory group on four measures of attention. In a similar study, Middleton, Lambert & Seggar (1991) delivered computerized rehabilitation tasks to two small groups of mixed acquired brain injury patients. One group received tasks targeting attention and memory abilities, the other reasoning and logical thinking. Both groups received 96 hours of educational training and 32 hours of computer-assisted treatment. They reported significant improvements on attention and memory tests (neuropsychological tests: administered at pre- and post-test) for both groups. There were therefore, no differential effects for the two different computerized programs. It is not possible to discount practice effects or the impact of the educational training in this study and the authors themselves indicate that the results "may not be construed as support for the efficacy of neuropsychological rehabilitation."

Gray, Robertson, Pentland and Anderson (1992) also carried out a randomized group study to assess the efficacy of computer administered attention training tasks.

Participants included 31 people with traumatic or non-traumatic brain damage of acute onset (i.e., closed head injury or stroke) who were randomly allocated to either computerized attention training or recreational computing. They attempted to demonstrate specificity of attention training by including tasks dependent on attention and non-attention abilities as outcome measures. The authors report "only minor differences" in attention functioning at the end of training but significant differences on three attention tasks were found at six month follow-up (PASAT, Digits Backward, Arithmetic). A weakness of this study is that participants varied substantially in time since injury and some were as early as seven weeks post-injury. Therefore, improvement secondary to spontaneous recovery cannot be ruled out.

Ruff and colleagues (1994) assessed the efficacy of THINKable, a computer-based multi-media program developed by IBM with 15 TBI subjects of moderate severity. The 15 individuals were divided into two groups which received attention and memory training in counterbalanced order. Pre- and post-test measures were obtained (neuropsychological tests), as well as 3 pre-treatment, 1 mid-treatment and 3 post-treatment measurements (computerized tasks and neuropsychological tests). They also examined behavioral ratings by subjects and significant others. They demonstrated small but consistent improvements on computerized attention tasks with mixed results for the neuropsychological attention tasks. Increased speed was a robust finding. Memory tasks showed similar results. Behavioral ratings for both attention and memory showed improvements, noted more strongly by significant others than by the subjects themselves. Findings for this study are positive, however, the test tasks that showed the most consistent improvements were very similar to the computerized tasks themselves. The authors argue for generalization of gains to real life evidenced by the improvements shown on behavioral report.

A more recent study, carried out by Sturm, Willmes, Orgass and Hartje (1997) investigated whether specific attention deficits need retraining. The computer tasks employed by these researchers trained four different aspects of attention: two intensity aspects, alertness and vigilance, and two selectivity aspects, selective and divided attention. 38 patients with unilateral vascular lesions received consecutive training in the two most impaired of the four attention domains. Participants received a total of 14 one hour training sessions for each attention function trained. These authors compared performance after specific attention training and non-specific attention training (i.e., did participants improve on divided attention after training in vigilance or just after training in divided attention?). Their results suggest that specific attention disorders do benefit from specific retraining, particularly deficits in alertness and vigilance, where improvement was only achieved after specific training. They also report specific training effects for divided and selective attention, however some task parameters such as response time also improved following non-specific training. The authors suggest that the more complex attention domains require elementary aspects of attention and thus benefited from improvements in the intensity aspects.

In a "semi-archival" study, Chen, Thomas, Glueckauf & Bracy (1997) compared Bracy's Process Approach (Bracy, 1985), a method of computer-assisted cognitive rehabilitation (CARC) to a more traditional approach. The experimental group included 20 individuals who had sustained TBI and received CARC and pre- and post-test neuropsychological measures. CARC exercises were organized hierarchically and focused on attention, visual-spatial abilities, memory and problem solving. The comparison group was 15 individuals with TBI were involved in "traditional" rehabilitation. This is not well described in their paper. Both groups made gains on neuropsychological measures, with the CARC group making gains on a larger number of tests, however, this difference was not felt to be substantial. Differences between groups in chronicity of injury and length of treatment make it difficult to draw firm conclusions from this study.

In addition to group comparisons, carefully controlled single case designs can provide important information about the efficacy of attention training. Gray and Robertson (1989) carried out a multiple baseline across functions study with three male brain injured participants. A multiple baseline design requires that a number of behaviors within one individual are identified and measured over time in order to provide baselines against which change can be evaluated. A treatment is considered to be effective when the level of the targeted behavior changes while the untreated or "control" behaviors remain the same. All three participants demonstrated improved performance on attentional measures (digit span, backward digit span, arithmetic) and no improvement on control measures following computerized attention retraining.

The above mentioned studies all evaluated attention retraining with a microcomputer based program. There is a small body of literature examining the efficacy of therapist delivered attention training. Sohlberg and Mateer (1987) evaluated the efficacy of a therapist delivered program, Attention Process Training (APT) (Sohlberg & Mateer, 1989). APT is a hierarchically organized treatment program with tasks designed to exercise sustained, selective, alternating and divided attention. They used a multiple baseline single case design with four participants. All were at least one year post-injury. Their study demonstrated more experimental control than the Gray and Robertson study (1989) in that they targeted their "control" variable once improvement was noted on the attention task. Participants received attention training following a period of baseline observation. Performance was measured using the Paced Auditory Serial Addition Test (PASAT) (Gronwall, 1977). The non-targeted variable was visual processing and it was not treated until performance on the PASAT demonstrated improvement. Visual process training was then instituted and performance was measured using the Spatial Relations subtest of the Woodcock Johnson Psychoeducational Battery (1977). The authors were able to demonstrate specific improvements in each of these outcome measures coinciding with time of treatment, suggesting that the effect was not due to general stimulation. Solhberg and Mateer also provided qualitative information about changes in the vocational or living status of their participants after participation in the rehabilitation program. Although this information was not collected in a systematic manner, it suggests that the attention training or some aspect of the rehabilitation program did generalize to improvements in the daily lives of the participants. Future studies should attempt to quantify these types of changes in a more systematic manner.

Nag and Rao (1999) evaluated the efficacy of therapist-delivered attention retraining with four individuals with TBI. Severity of injury was varied and time since injury ranged from 3 to 48 months. They focused on improving deficits of focused, sustained and divided attention. They used a pre- and post-test design with dependent measures for three levels. Level 1 assessed improvement on criterion attention tests; level 2 assessed generalization to tasks measuring other cognitive functions such as information processing speed and memory, and level 3 assessed generalization to daily life as indicated by symptom ratings and changes on a neurobehavioral rating scale. They found that for all subjects, divided attention and behavioral ratings showed the most improvements, followed by improvements in focused attention. Sustained attention showed small improvements. They were able to demonstrate specificity of improvement to attention abilities because no improvements were shown on level 2 generalization tasks.

In the pursuit of generalization to real life activities, Wilson and Robertson (1992) utilized therapist delivered attention training with a single subject to target a specific behavior, attentional slips during reading. They utilised a changing criterion design where the subject moved to the next level of training when he achieved a pre-set criterion of performance. The training strategy was a simple behavioral shaping strategy aimed at increasing the length of time the subject could concentrate on reading without attention or concentration slips. Training began with minimum periods of reading with planned breaks. The duration of reading was increased while the duration of breaks was reduced. The subject was also trained at reading in the presence of background noise. The treatment appeared efficacious in helping the subject to be able to read for longer periods of time and to find the information he read to be more useful, hence this study appears to demonstrate some semblance of practical as well as statistical significance.

Franzen and Harris (1989) utilized a modified multiple baseline design to improve attention and concentration skills specific to memory and abstract reasoning in a 25 year old man who sustained a severe traumatic brain injury. Treatment consisted of seven sessions of training on four tasks related to visual attention and auditory memory. This training was followed up by home practice sessions. The second phase of treatment consisted of nine sessions of practice on two tasks of abstract reasoning/problem solving. Dependent measures for attention were the Knox Cube Tapping Test (Stone & Wright, 1980) and the memory scale of the Luria Nebraska Neuropsychological Battery (LNNB). Dependent measures for abstract reasoning/problem solving were the Wisconsin Card Sorting Task (WCST) (Heaton, 1987), the Booklet Category Test (DeFillipis & McCampbell, 1979), and the Intellectual Processes Scale of the LNNB. They demonstrated specificity of their training above and beyond spontaneous recovery or general practice effects as no improvements were evidenced on abstract reasoning tasks following the attention training. Improvements were demonstrated following the abstract reasoning/problem solving training with no further improvements on the attention tasks. Attention task performance did improve following the attention specific training. They also demonstrated improved speed on the Stroop task (Golden, 1978) following attention specific training only. These authors did not include any specific measures of generalization to daily life but reported that the subject was employed at a higher level job four years post-injury and was reporting adequate attention functioning and adequate memory functioning except during times of stress.

Cicerone and colleagues (1996) carried out a retrospective evaluation of a multi-faceted neuropsychological rehabilitation program of which practice on “paper and pencil” and “real-life” activities aimed at approving attentional abilities was one part. They utilized pre- and post-test neuropsychological test data and symptom ratings for 20 patients with mild TBI. They divided patients into two groups: good outcome (GO) and poor outcome (PO) based on ability to resume pre-injury or other productive activities. The GO group evidenced improvements on tests requiring complex attentional abilities such as rapid mental processing, selective and sustained attention. They also showed a significant reduction in symptom reporting. Conversely, the PO group demonstrated fewer improvements overall and no improvements on tests of attention. Similarly, none of the self-reported post-concussive symptoms improved either. In fact, the authors reported some clinically significant worsening. The authors stated that "it is impossible to determine from the present study whether neuropsychological rehabilitation was responsible for the improvements…for patients with good outcomes, or even whether these improvements were responsible for the good outcomes." Control over extraneous variables is minimal because of the retrospective nature of the study. However, this study does highlight the very important point of heterogeniety in TBI populations and of different responses to therapeutic intervention.

Despite the generally positive results discussed above, some researchers have failed to find results supportive of the efficacy of attention retraining. Ponsford and Kinsella (1988) evaluated a computer mediated attention training program aimed at improving speed of processing. This approach to attention rehabilitation was based on the findings of Van Zomeren and colleagues (1984), and others who have suggested that brain injury reduces the speed of processing which in turn reduces information processing capacity resulting in deficits in controlled attention. A single case multiple baseline design was implemented for ten severely brain injured individuals. Although participants demonstrated improvement on neuropsychological outcome measures, there was no difference in slope between the baseline and the training phases, therefore the authors concluded that spontaneous recovery was responsible for the improvement over the study period.

Gansler & McCaffrey (1991) carried out an ABA single-case experimental design with four subjects investigating the efficacy of an attention remediation program comprised of paper and pencil and computerized tasks. Subjects in this study were four to 27 years post-injury. They assessed reaction time and sustained attention, as well as activities of daily living and ratings of depression, anxiety and anger. In addition, they carried out pre and post-test neuropsychological assessments using some standard neuropsychological test instruments. Their results were quite variable, with only one subject showing a consistent improvement. However, examination of their results reveals a possible ceiling effect for the vigilance task with one subject whose pre-treatment scores were below ceiling showing an improvement. In addition, one subject had a diagnosis of paranoid schizophrenia. An interesting finding reported in Gansler and McCaffrey's study was that subjective ratings of satisfaction with activities of daily living improved for the four subjects despite no consistent improvement on the neuropsychological or reaction time and vigilance tasks.

Malec, Jones, Rao & Stubbs (1984) implemented a randomized double cross over design with ten individuals with TBI to determine if regular practice with a video game requiring sustained attention would enhance recovery of sustained attention in the early phases of brain injury rehabilitation; their participants were six months post injury or less. Dependent measures were the Stroop Test, letter and symbol cancellation tasks, and reaction time (RT). Participants did show improvement on measures of sustained attention. The authors controlled for the effects of spontaneous or natural recovery by examining change scores after a period of "treatment" (video games) and a period of no treatment. The results indicated no more improvement in sustained attention performance as a result of a week of video games than as a result of no treatment. This study provides evidence that practice with video games does not provide a treatment effect above and beyond what would be expected to occur naturally in the first six months following TBI. Although an interesting and well controlled study, it is important to keep in mind that the video games were standard commercial games and were not specifically designed to be used as remediation materials. In addition, the treatment period used in this study was very short and may not have been long enough for any change to take place.

Park, Proulx and Towers (1999) investigated the efficacy and specificity of Attention Process Training (APT) materials (Sohlberg & Mateer, 1987) with 23 participants whose brain injuries were classified as severe based on duration of post-traumatic amnesia. Dependent measures were the PASAT (Gronwall, 1977), the consonant trigrams task (Brown, 1958), and the Beck Depression Inventory (BDI) (Beck, 1987). The authors postulated that training would improve sustained attention performance (PASAT) but not memory performance (consonant trigrams). Participants underwent 40 hours of APT and also received adjunct counselling. TBI subject data was compared to normative data for the consonant trigrams and PASAT administered at a one week interval. Results indicated no change in mood as evidenced by no improvement on BDI scores. There was improved performance on the PASAT, however the control group also demonstrated a similar pattern and the authors interpreted their results as being indicative of specific practice on the PASAT and not of improved attentional abilities. For the trigrams task, the TBI group improved for the short delay condition only. The control group did not show an improvement from test one to test two. This lead the authors to conclude that some aspect of the training program improved performance on the trigrams task. There are a number of limitations to this study such as different inter-test intervals for the control and TBI groups. In addition, the choice of tasks were very narrow and did not sample a range of attentional abilities.

Gauggel and Neimann (1996) evaluated the efficacy of a computer-assisted attention training program with four patients: two with TBI and two with stroke. Patients were 1 to 16 months post-injury/lesion. Two baseline measures were obtained to control for spontaneous recovery and practice effects, followed by a post-test. Only two patients showed improvement on one of the attention tests, however one was discounted as being due to spontaneous recovery. The authors described "tendencies toward improvement." Despite good controls for practice effects, this study was seriously limited by the fact that all patients except one were no more than four months post-injury/lesion. It is well documented that spontaneous recovery is most rapid at this time (Lezak, 1995).

Neurophysiological Indices of Improvement After Rehabilitation

Electrophysiological measures as indicators of outcome after rehabilitation have only recently been employed. These methods have potential utility in the assessment of underlying cerebral change after rehabilitation when correlated with functional improvement. Event related potentials (ERPs) are a transient series of voltage oscillations in the brain that can be recorded from the scalp in response to the occurrence of a discrete event (Donchin, 1981). Auditory event-related potential components such as Nd, N200, and P300 have been shown to correlate with attention functioning in signal detection studies. Polich (1998) describes the P300 as "a sensitive temporal measure of neural activity underlying the processes of attention allocation and immediate memory." When extraneous variable are well controlled, the P300 can discriminate between mildly impaired patients with dementia and normal controls (Polich, 1998). The P300 component has also been shown to be both reduced in amplitude and delayed in latency in the TBI population

(Heinze et al, 1992; Papincolaou, Levin, Eisenberg, Moore, Goethe & High, 1984; Baribeau, Ethier & Braun, 1989; Campbell et al., 1986; Rugg, et al., 1988). The P300 is regarded as a neurophysiologic index of attention capacity in humans. It is thought to index the attentional and memory related processes involved in updating, or revising of templates in memory (Polich, 1998; Deacon-Eliot, Campbell, Suffield, & Proulx, 1987). It involves maintaining a memory for a target, stimulus evaluation, matching and comparison ability, decision making, and the initiation of a response. The N200 is associated with evaluation of stimulus information required for response selection (Gevins & Cutillo, (1971).

Keren and colleagues (1998) recorded ERPs from 16 patients with TBI on three different occasions during the first six months post-injury. They found shortening of the latency of both the P300 and N200 components during recovery. These changes also correlated with improvement on neuropsychological tests. The authors suggested that ERPs provide "a useful physiologic index that opens a window into brain function changes that are associated in specific ways with cognitive recovery after severe CHI (closed head injury)."

Baribeau, Ethier & Braun (1989) assessed auditory event-related potentials as neurophysiological indices of selective attention before and after an intensive, computer-dispensed cognitive rehabilitation program. They utilized 21 individuals with TBI and also employed a control group of 22 individuals with TBI matched for age, sex and education. They found the neurophysiological indicators to be sensitive to treatment condition, however, there were no changes in error rates or speed. They report reduced N100 latency, increased amplitude of the P1-N1-P2 component and increased amplitude of the Nd for the left ear only for their experimental group. The authors interpreted their results as suggesting

Stone and Raskin (1996) used quantified EEG as a measure of efficacy in a rehabilitation study evaluating the efficacy of prospective memory training with two participants with TBI. These participants demonstrated an abnormal frontal distribution of alpha activity prior to training which reverted to a more typical, posterior distribution after training. Raskin (1996) also measured P300 before and after prospective memory training. The participants demonstrated reduced P300 latency after training. Solhberg and colleagues (in press) reported reduced P300 amplitudes in brain injured patients as compared to controls. However, they noted no change in ERPs following participation in Attention Process Training (APT) (Sohlberg & Mateer, 1987) despite functional improvements on neuropsychological tests. At present it appears that findings are mixed. However, there is some evidence pointing to the possibility of brain related changes as a consequence of direct interventions and practice on specific cognitive skills.

Current Limitations of the Rehabilitation Literature

Despite encouraging results reported by some researchers, there are some substantial weaknesses in this body of literature. One problem concerns generalizability of attention retraining. Improvements on psychometric measures have been reported quite consistently but generalizability to everyday life activities has not been adequately demonstrated. Few studies have attempted to use ecologically valid measures of every day attention functioning (Ponsford & Kinsella, 1992). In addition, test measures that are used to assess improvements in attention are often quite similar to the attention training tasks themselves. Therefore, it is difficult to rule out simple practice effects.

improvements in attention are often quite similar to the attention training tasks themselves. Therefore, it is difficult to rule out simple practice effects.

Another difficulty is that the heterogeneity inherent in the TBI population makes group comparison studies very difficult. These patients often differ in terms of severity and type of brain damage, cognitive functions affected, extracranial complications, family support, emotional functioning and behavioral deficits. The merits of neuropsychological rehabilitation may differ depending on these factors. An additional problem with group comparison studies is the ethical dilemma of assigning patients to no treatment control groups. Diller and Ben-Yishay (1987) have suggested varying the form of treatment across groups. Single-case experimental designs can be used but they present their own set of problems such as inadequate baseline measurements. In a recent review, Robertson (1997) pointed out some further weaknesses in this research area when he suggested that most of the research to date has largely been carried out in a theoretical vacuum, without clarifying which aspect of attention is being targeted. He suggests that non-specific attention retraining be abandoned.

Importantly, attention training is often one component of a more comprehensive rehabilitation program that may also include awareness training or psychotherapy; therefore, it remains unclear whether attention training per se is beneficial (Goransen, 1997). Some programs such as APT (discussed above) consist of primarily repetitive exercises and drills but also contain some elements aimed at increasing awareness of problems and finding ways to facilitate better coping. It is difficult to attribute specific gains to a multi-dimensional remediation program. A number of studies include a psychotherapeutic element as part of the intervention but do not evaluate its impact on outcome (Park, Proulx,

& Towers, 1999; Middleton et al., 1991). In a large meta-analysis, Carney and colleagues (1999) reported no treatment effect when cognitive rehabilitation was compared with another form of treatment. They stated that "we must test the differential effects of general stimulation versus cognitive rehabilitation."

Although the research literature has primarily examined the efficacy of direct interventions (i.e., targeted practice), in clinical practice other interventions are also employed. These interventions include practical suggestions to reduce noise or visual distraction, to perform only one task at a time, to break complex tasks down into smaller tasks, and to reduce fatigue. Mateer and Raskin (1996) suggest that these interventions have face validity, but little in the way of empirical evidence to back them up. In order to begin to look at these different elements, Wilson (1993) suggests asking questions that tease out the effects of particular rehabilitation procedures as they are applied to particular patient groups.

Few studies provide data relevant to these issues. Ruff and colleagues (1989), conducted a randomized group design study aimed at separating specific treatment effects from those of stimulation and social support. In their study two groups of 20 subjects received different treatments. Their control group received sessions focusing on psychosocial adjustment, leisure, activities of daily living, coping skills and health. The experimental group received computerized training in attention, memory, spatial integration, and problem solving. Both groups received 50 minutes of group psychotherapy at the beginning of each day. At post-test, both groups improved significantly on neuropsychological measures in all areas except for spatial integration. The relative efficacy of the two treatments was not demonstrated but statistical trends in the data suggested that the experimental group made larger gains in almost all areas. Their data suggest that the enriched environment characteristic of the therapeutic milieu yields some benefits, even in the absence of targeted, neuropsychologically based training. Their data also suggests that specific training may have some benefit above and beyond what is provided by a supportive therapeutic situation but this conclusion is tentative. In a later paper, Ruff and Niemann (1990) reported on the impact of cognitive remediation versus psychosocial day treatment on emotional and psychosocial variables. They predicted an increase in affective distress after participation in cognitive remediation and a decrease after participation in the day program. Using the above noted design, they found that their hypothesis was not supported. Both groups demonstrated a reduction in symptoms of psychosocial distress. These findings underscore the importance of considering separately the impact of both cognitive rehabilitation and psychosocial interventions in outcome studies.

Schmitter-Edgecombe, Fahy, Whelan & Long (1995) used supportive group therapy as a comparison treatment to control for the effects of group intervention in their study examining the efficacy of memory notebook training. There were no differences between groups (n=4) on laboratory based measures of memory, retrospective report of everyday memory failures and on measures of symptom distress, however a significant difference was found for observed everyday memory failures in favour of the memory notebook group. Ponsford and Kinsella (1988) looked at practice on a computer mediated attention training program and compared it to practice plus therapist feedback. Results were inconclusive but suggested that some participants did respond to therapist feedback and reinforcement.

Sohlberg, McLaughlin, Pavese, Heidrich and Posner (in press) were interested in comparing Attention Process Training (APT) (Sohlberg & Mateer, 1987) with a placebo condition of supportive counselling, relaxation training and brain injury education. Fourteen individuals with brain injury were divided into two groups and received 24 hours of individually administered APT over 10 weeks and 10 hours of individual therapeutic support over 10 weeks in counterbalanced order. Dependent measures were administered at pre-test and after each experimental condition. Outcome measures included neuropsychological tests sensitive to attention dysfunction, cognitive marker tasks (tasks that have been studied by positron emission tomography (PET) and for which there are putative neuroanatomical correlates), adaptive functioning questionnaires and a structured interview. Results indicated practice effects and improvement after participation in both conditions. An interesting finding was a significant effect for order. Improvement for participants who received the placebo condition first was not observed until after APT administration. For those participants who received APT first, a continued improvement was noted after placebo. The authors suggest that APT helps to mobilize cognitive resources and results in treatment effects in follow-up. This finding held for both questionnaire and cognitive test data. Structured interview information was examined as changes in three areas: everyday functioning, psychosocial functioning and cognitive functioning. The number of changes reported was greater after APT than after placebo. However, more psychosocial improvements were noted by participants after placebo and more cognitive improvements were noted after APT. Taken together, the data from these studies strongly suggest that the non-specific or psychosocial interventions that are often part of a rehabilitation program do exert an effect and should not be ignored in efficacy studies.

PURPOSE OF THE STUDY

As discussed above, studies of the efficacy of attention retraining have, by and large, focused on the "nuts and bolts" of the attention training (e.g., the computer task or the specific exercises designed to improve attention functioning). The "nonspecific" or "psychotherapeutic" effects of receiving support, education, and positive feedback from a therapist are generally ignored in the literature. Therapists practicing cognitive rehabilitation will attest to the importance of this feature of the rehabilitation process (D. Allison, personal communication, September 1997). In addition, compensations are used frequently by rehabilitation therapists, but there is little in the way of empirical evidence for their efficacy. The most likely reason for the lack of attention focused on these "other" aspects of the rehabilitation process is difficulty in the operationalization of these factors.

The primary goal in carrying out this study is to determine if there is a specific effect for the administration of pure attention training above and beyond a supportive, adjustment-oriented approach. As discussed above, the limited research bearing on this question to date, (Ruff et al., 1989; Sohlberg et al., in press; Schmitter-Edgecombe et al., 1995) suggests that neuropsychologically focused rehabilitation materials targeting specific cognitive domains may be superior to a more adjustment focused approach in terms of performance on neuropsychological measures. To attempt to address the issue of generalizability, outcome will be assessed using ecologically valid neuropsychological attention measures and daily charting of attention failures.

A secondary goal is to determine if neurophysiological correlates of attention change after attention retraining, implicating the occurrence of underlying neural change in humans. Event related potentials (ERPs) will be recorded for this purpose. Finally, this study aims to look at self-efficacy beliefs and reporting of attention problems to see if they change over the course of participation in a rehabilitation program, and to note if they are impacted differentially by two treatments.

It was predicted that neuropsychological test scores and electrophysiological variables would show the most change after participation in the pure attention training condition. Change on these measures after participation in the adjustment-focused condition is expected to be minimal. With respect to ERP components, it is predicted that the P300 and N200 components will show differences after participation in the attention training condition. More specifically, a decrease in latency of the both the P300 and N200 components may be observed. In addition, a decrease in the negativity of the N200 is also predicted. It is predicted that P300 amplitude may also show change but specific hypotheses about directionality of this change are not offered. It is also predicted that self-efficacy beliefs and number of reported attentional problems will change as a function of participation in the rehabilitation program.

METHOD

Participants

Potential participants were recruited from various sources in the Greater Victoria area, including referrals to the Head Injury Rehabilitation Outpatient Program at the Gorge Road Hospital in Victoria, BC and to the Vancouver Island Head Injury Society. 21 potential participants were interviewed by phone. Of these, ten underwent a brief neuropsychological screening battery. Seven participants, meeting inclusion criteria were selected for participation in the study. Two participants dropped out of the study. Prior to entry into the study, participants took part in a clinical interview and a brief neuropsychological assessment in order to carefully document their cognitive difficulties. Tests administered included: the Victoria Symptom Validity Test (VSVT) (Slick, Hopp, Strauss, 1997), Wonderlic Personnel Test (WPT), The Stroop Test (Victoria version), The Brief Test of Attention (BTA), the Paced Auditory Serial Addition Test (PASAT) (Gronwall, 1977), Visual Search and Attention Test (VSAT), Symbol Digit Modalities Test (SDMT) (Smith, 1991), and the Trail Making Test. The Depression Scale developed by the Rand Corporation was also administered. It is a very short questionnaire that correlates reasonably well with the Beck Depression Scale, $r = .70$, $p < .05$. It contains only items of an emotional nature and does not contain any of the vegetative or cognitive items that may be confounded with brain injury symptomatology.

Participants selected were at least one year post injury, and evidenced an injury of at least moderate severity as defined by either a Glasgow Coma Scale (GCS) of 8 to 12, loss of consciousness of 30 minutes or more, a period of post traumatic amnesia (PTA) of at least one hour, or evidence of a brain injury documented by neuroimaging studies.

Participants were excluded after the administration of the initial neuropsychological test battery if they were able to successfully complete the Paced Auditory Serial Addition Test (PASAT) (Gronwall, 1977). Participants admitted to the study obtained scores of 1.5 standard deviations or more below the mean on this measure. The PASAT is a very sensitive test of deficit in even mildly brain injured individuals, and it can be demanding and frustrating for non-brain injured people (Spreen & Strauss, 1998). Therefore adequate performance on this test would preclude the necessity of attention retraining. Because this is a single case experimental design study and individual variability is of interest, participants were not excluded on the basis of seizures, or previous TBIs. In addition, participants were not excluded on the basis of a prior history of substance abuse. Alcohol abuse is common in individuals who sustain traumatic brain injuries (Grafman & Salazar, 1987), therefore to exclude participants on this basis would not be representative of the characteristics of the population of interest. However, participants were screened to determine if they were currently abusing either alcohol or street drugs. Efforts were made to exclude participants who were in litigation. However, because litigation is a frequent factor in this population, participants were not excluded on these grounds. Two participants were in litigation at the time of the study. A symptom validity measure was administered to all participants as a check for adequate motivation.

Participant 1

This participant was a 58 year old woman. She was injured in a bicycle/motor vehicle accident 26 months prior to her participation in the study. She was in a coma for nine days. CT scan revealed a subdural hematoma with midline shift, skull fracture and right temporal contusion. Additional injuries included a dislocated shoulder. She remained in hospital for seven and a half weeks. Participant 1 also sustained a serious head injury approximately forty years earlier which resulted in the loss of hearing in her left ear. She lost some hearing in her right ear due to the second accident. Discussion with her audiologist indicated that with the use of a hearing aide, her hearing was adequate for the purposes of this study.

Participant 1 worked as a receptionist for 17 years prior to the accident. She also did bookkeeping for a family business and sold knitting machines as her own business. She has given up all of these jobs since the accident. She lives at home with her husband and has a supportive extended family. Her main complaints were decreased concentration, reading comprehension, math skills and fatigue. Medications at the time of her participation in the study included Niacin for high cholesterol and Estrogen.

Participant 1 underwent a recent neuropsychological assessment so scores from this assessment were used for the purposes of screening for the study. Intelligence was in the Average range. Relevant scores were as follows:

Trails B	70^{th} %ile
BTA	9^{th} %ile
Naming	6^{th} %ile
Reading speed	1^{st} %ile
Reading comp	13^{th} %ile

Participant 2

This participant was a 22 year old male. He was injured in a motor vehicle accident 45 months prior to participation in the study. Loss of consciousness was reported to be brief and he reported a period of post traumatic amnesia of three days. This participant was hospitalized for three days. No neuroimaging or previous neuropsychological data was available for this young man.

At the time of participation in the study, Participant 2 was living at home with his parents and holding down a part-time job. He was also taking courses at college. His main complaints focused on short term and long term memory problems and difficulties with attention and concentration. Participant 2 also suffered from fairly regular headaches (e.g., twice per week). He complained of fatigue, low energy and feelings of depression. He was taking no medication at the time of the study. Participant 2 was in litigation during the study.

Neuropsychological screening indicated that this participant was of Average overall intelligence and performed adequately on measures of symptom validity. Performance on screening tests was as follows:

VSAT	Left - 3rd %ile	Right - 5th %ile
Trails A	54 %ile	
Trails B	38th %ile	
BTA	9th %ile	
PASAT	<1st %ile	
Stroop	1st %ile	
SMDT	10th %ile	

Participant 3

This participant was also a 22 year old male. He was injured in a motor vehicle accident 29 months prior to his participation in the study. He was in a coma for three weeks and was hospitalized for approximately 12 weeks. CT scan indicated focal hemorrhage in the right hemisphere. There is a pre-morbid history of Attention Deficit Disorder (ADD).

He was living with a roommate at the time of the study and was beginning his first job since the accident. Due to difficulties in getting time off work, this participant did not participate in many of the sessions of the adjustment focused module (Active Control condition). Therefore, his treatment was modified. He underwent an extended baseline period (12 weeks) and participation in the Attention Training module only.

Participant 3's main complaints were short term memory problems, attention problems, quick temper, fatigue and generally being "a different person than before the injury." This participant indicated that his Attention Deficit Disorder was no longer causing him problems prior to the accident but that the accident "brought back the attention problems 100%." He was not taking any medications at the time of his participation in the study. Participant 3 was in litigation during the study.

Participant 3 was undergoing neuropsychological assessment at the time of his screening for this study and those scores were used to determine his eligibility. They were as follows:

Trails A	44th %ile
Trails B	50th %ile
PASAT	<1st %ile
Stroop	4th %ile
SMDT	<1st %ile

<u>Participant 4</u>

This participant was a 34 year old male. He was injured in a motor vehicle accident nearly 12 years (144 months) prior to his participation in the study. He was in a coma for eight weeks and sustained a right sided injury resulting in left sided blindness and left sided hemiparesis. He has not lived independently since this accident and resided at a group home living semi-independently. Prior to the accident he worked as a labourer and has not worked since the accident. There is a history of sexual offending post-injury and he was taking Androcure at the time of his participation in the study. Premorbid history is positive for alcoholism. He has not used alcohol post-injury.

Participant 4 complained of a poor memory for numbers, names, and appointments, word finding difficulties, poor attention and distractibility. Due to transportation difficulties this participant was not able to come to the University for a neuropsychological screening. He was administered the PASAT by an on site worker and was unable to complete it.

Participant 5

This participant was a 40 year old male. He was injured in an assault that occurred 15 months prior to his participation in the study. He reported being unconscious for approximately two days; there is a considerable period of post traumatic amnesia. No neuroimaging was available for this participant.

He worked as a carpenter prior to the accident and has been unable to work since. At the time of his participation in the study he was living with a roommate and was very unhappy with his living situation. His main complaints centered around concentration problems, reading difficulties, math difficulties and problems sleeping. He also complained of depression. At the time of his participation in the study he was taking Prozac for depression and Restoral for sleep.

Neuropsychological screening indicated that this participant was of Average overall intelligence and performed adequately on measures of symptom validity. Performance on screening tests was as follows:

VSAT	Left - 10th %ile	Right - 8th %ile
Trails A	12th %ile	
Trails B	1st %ile	

BTA	<2^{nd} %ile
PASAT	<1^{st} %ile
Stroop	<1^{st} %ile
SMDT	1^{st} %ile

<u>Participant 6</u>

This participant was a 33 year old woman. She was involved in a motorcycle accident five and one half years (68 months) prior to participation in the study. She did not lose consciousness but reported a period of post traumatic amnesia of three days. She was hospitalized for 54 days due to serious orthopedic and facial injuries. Extensive reconstructive surgery was required. She suffers from diplopia as a result of the accident.

At the time of participation in the study this participant had a three month old baby and was staying at home to care for him. Her main complaints focused around memory difficulties, difficulty paying attention to auditory information and fatigue. She was taking no medications at the time of participation in the study.

Neuropsychological screening indicated that this participant was of Average overall intelligence and performed adequately on measures of symptom validity. Performance on screening tests was as follows:

Trails A	89^{th} %ile
Trails B	73^{rd} %ile
BTA	55^{th} %ile
PASAT	5^{th} %ile
Stroop	50^{th} %ile
SMDT	99^{th} %ile

This Participant discontinued her participation in phase two of the study due to the demands of her baby.

Participant 7

This participant was a 45 year old male. He was injured in a motor vehicle accident four and a half years (54 months) prior to his participation in the study. He reported that he lost consciousness briefly and there was a period of post traumatic amnesia of at least one hour. A CT scan was normal but he suffered detachment of the retinas.

Participant 7 owned a landscaping business and has not been able to work for approximately two years due to difficulties related to the accident. His main complaints focused on nearly constant headaches, balance problems, poor sleep, fatigue, inability to consolidate new memories, word finding problems, forgetting what he is talking about. He also reported increased irritability and bouts of depression since the accident. He was taking no medications at the time of his participation in the study.

Participant 7 was undergoing neuropsychological assessment at the time of his screening for the study and those scores were used to determine his eligibility. Overall level of intellectual ability was High Average. Performance on measures of symptom validity was adequate. He obtained the following scores:

Letter-Number	5^{th} %ile
Digit Span	5^{th} %ile
BTA	13^{th} %ile

This Participant dropped out of the study in the second phase. Injury characteristics for all participants who completed the study are presented in Table 1.

Table 1.

Participant Characteristics

	Gender	Age	TSI	Neuroimaging	LOC
1	Female	58	(1) 26 mos (2)40 yrs	Subdural hematoma with midline shift, skull fracture right temporal contusion	9 days coma
2	Male	22	45 mos	n/a	Brief with 3 days PTA
3	Male	22	29 mos	Focal right hemisphere hemmorhage	3 weeks coma
4	Male	34	12 yrs	Right sided injury with left hemiparesis and blindness	8 weeks coma
5	Male	40	15 mos	n/a	2 days with significant PTA

Procedures

Study Design

A modified single case multiple baseline cross over design with seven participants was utilized. This design was chosen for several reasons. Firstly, focusing on group effects may obscure or ignore important differences among participants within the group. In a rehabilitation study individual differences provide important information about patient/treatment interactions that can be applied to individuals with similar characteristics. Secondly, statistical as opposed to clinical significance is emphasized in group studies (Graves, 1991). Kazdin (1984) has indicated that clinical significance is a more stringent criterion than statistical significance because many statistically reliable effects can be obtained without clear or detectable impact on every day client functioning. Hayes and Leonhard (1991) suggested that analysis at the level of the individual is "scientifically defensible and much more applicable to the clinical environment than are group comparison designs." Gianutsos (1991) describes single case designs as having "great potential for introducing scientific rigour into the assessment of neuropsychological rehabilitation." Sohlberg and Mateer (1989) describe group designs as being interested in variability between groups and therefore not effective in examining behavior change in individuals over time. In group studies, individuals are often excluded on the basis of pre-existing learning difficulties or alcohol abuse histories. This results in research data only being applicable to a subset of individuals with traumatic brain injuries. Due to the variability in TBI populations, the single case experimental design is the design of choice. In addition, participants serve as their own controls, providing information about the effectiveness of different treatments within the same individual. This provides stronger data than group studies where a different treatment is applied to individuals in two different groups and it is assumed that there are no important differences between the individuals that account for any observed treatment effect. The within-subjects or single case design also provides more powerful control when examining neurophysiological variables. A number of constitutional factors such as age, gender, handedness, intelligence, and biological factors such as circadian rhthyms (see Polich, 1998 for a review) have been shown to influence ERPs; therefore recording within subjects serves to reduce this source of error variance.

The multiple baseline design was selected because it provides adequate controls for spontaneous recovery and for the effects of stimulation and therapist attention. The cross-over design allows for examination of order effects. For these reasons, this design was felt to be the most appropriate for investigating the particular questions of interest. This study employed three six week phases.

After an initial clinical interview and neuropsychological screening, participants were selected into the study and randomly assigned to one of two groups. Both groups participated in three baseline test sessions, administered two weeks apart. There was a staggered start with Group One beginning the study six weeks before Group Two. This was instituted in order to allow for the Active Control condition to include all participants at once and to allow for the administration of APT both prior to and following the control condition.

Following the six week baseline period Group One (Participants 1 & 2) received individually administered Attention Process Training (APT) twice per week for one hour for six weeks (for a total of 12 hours). At this time, Group Two (Participants 3, 4 & 5) began the baseline condition. Following the APT phase for Group One and the baseline phase for Group Two, the Active Control condition commenced for both groups. The Active Control condition was an adjustment-focused module and will be described in detail below. The Active Control condition consisted of two one hour sessions per week for six weeks (for a total of 12 hours). Following completion of the Active Control (adjustment focused module), Group One's participation in the study was completed. Group Two then went on to participate in APT administered in a group format (twice per week for one hour each time for a total of 12 hours). Dependent measures were obtained at two week intervals throughout the study. There was a total of nine test sessions over the entire study including baseline measurements. Three test sessions per experimental condition was felt to be both informative and practical. This is also a stronger experimental design than other studies in this area that utilized two test sessions per condition (Solhberg & Mateer, 1987). Participants were at least one year post-injury and the baseline period is the same duration as the treatment periods so any spontaneous recovery that may still be occurring should be noted during the baseline phase.

Testing was carried out by a research assistant not involved in the provision of the rehabilitation procedures. The therapist was the same for both conditions to control for therapist effect. A substitute therapist provided treatment to both groups for two sessions during the Attention Process Training phases. Treatment delivered in this study was carried out primarily in a group format. This was chosen to reflect the way that neuropsychological rehabilitation is typically carried out in the community in this time of cost-efficiency. Results drawn from a one on one therapeutic interaction would not be generalizable or useful to therapists working with clients in a group setting. However, Group One participants did receive APT in a one on one format. This was done in order to investigate any differences attributable to individualized treatment delivery.

Attention Retraining Module

The attention retraining module consisted of the Attention Process Training (APT) materials (Sohlberg & Mateer, 1987). As mentioned earlier, the APT materials consist of hierarchically organized treatment tasks for each of the five levels of attention outlined in Sohlberg and Mateer's componential model of attention: focused, sustained, selective, alternating, and divided attention. The materials include paper and pencil tasks; some exercises are presented on audiotape. Other activities include multi-tasking such as sorting a deck of cards and counting at the same time. Efforts were made to ensure that this condition focused purely on the practice of cognitive tasks. Discussion of personal problems was discouraged during this phase of the study. However, the presence of a therapist and/or group members did undoubtedly lend an element of supportive encouragement to this condition. Any components of the APT tasks that involved more than cognitive exercises and could be argued to play a role in fostering increased awareness or encouraging problem solving were not used in order to focus only on targeted cognitive exercises. Similarly, recording of participants' performance was carried out by the therapist because client tracking of results is often used to promote awareness.

APT tasks were administered in the same fashion for the individually administered (Group One) and group administered (Group Two) condition. Paper and pencil tasks were administered repeatedly with participants working on improving their speed. Audiotapes were delivered in a hierarchical format of increasing levels of difficulty. All participants were started with the same tape and were moved onto more difficult tapes when they reached criterion (two or less errors). This allowed for participants to move through the exercises at their own pace. In the group administered APT condition, participants worked on timed tasks at the same time. While one participant was doing an audiotape exercise, the others were involved in tracking the person's errors in order to keep the group cohesive and all members involved.

Adjustment-Focused Module (Active Control Condition)

This module was designed with the purpose of implementing the "other" aspects of the rehabilitation process such as awareness training, problem solving, and use of compensatory techniques. There was no direct retraining of cognitive functions in this condition. This module was outlined in a manual format (see Appendix D) with specific topics covered in each session (see below). All participants in the study participated in this condition at the same time. One exception was Participant 3 who was unable attend these sessions due to employment commitments. He underwent as extended baseline phase as discussed earlier.

Session #1 - Psychoeducation about TBI
Session #2 - Goal setting, discussion of attention problems
Session #3 - Goal setting, attention problem self-monitoring
Session #4 - Use of compensations
Session #5 - Memory problems and compensations
Session #6 - Cognitive restructuring
Session #7 - Cognitive restructuring continued
Session #8 - Emotional stages of recovery
Session #9 - Post-concussive syndrome and headaches
Session #10 - Relaxation - Self-hypnosis and Progressive Relaxation
Session #11 - Problem solving
Session #12 - Problem solving and wrap up

Measures

Neuropsychological Measures

To assess the efficacy of the rehabilitation procedures, selected subtests of the Test of Everyday Attention (TEA) (Robertson, Ward, Ridgeway & Nimmo-Smith, 1996) were administered. This test requires participants to carry out tasks taken from daily activities that depend heavily on attention, such as searching a telephone directory or a map. It is thought that this test provides a more ecologically valid assessment of attention abilities than using the traditional laboratory based neuropsychological measures of attention. This measure was also developed on a solid theoretical basis of the structure and function of attention. In addition, the TEA has three parallel versions to account for practice effects; the subtests chosen for this study demonstrated high test-retest reliability. The three different versions (A, B, C) of the TEA were administered in alternation, every two weeks, such that six weeks elapsed between administrations of the same version. Each version was administered three times for a total of nine test sessions (3 per condition). It is felt that length of time between administrations of the same version of the test accounts for any improvement due to memory. In addition, memory effects should not pose a problem due to the nature of the TEA subtests (timed subtests that do not require one to provide specific answers that could be remembered). Similarly, learning effects should be minimal because there is no novel problem solving component to any of the tasks. Unfortunately, there is no currently available test of attention known to the author that is available in nine alternate forms.

Dependent measures were administered at two week intervals for six weeks during a baseline period when no rehabilitation training was being provided in order to ensure stability of performance level. Barlow and Hersen (1984) suggest that three observations during a baseline period is adequate to establish a trend in the data. Measures were administered again at two week intervals (during and after each six week phase) for a total of nine test sessions.

Three subtests of the TEA were administered. The Lottery subtest is a ten minute test which requires participants to listen for winning lottery numbers presented on audiotape. In a factor analysis carried out by the test authors, this subtest loaded on a sustained attention factor. The Map Search subtest was also administered. For this task, participants were required to search for symbols (i.e., a knife and fork representing the location of restaurants) on a coloured map of the Philadelphia area. They were timed to see how many symbols they could locate in two minutes. This test loaded on a visual selective attention factor together with the Stroop Test and the D2 Cancellation Test. It was also shown to correlate with three measures of functional status. Robertson and colleagues (1996) stated that no other existing measure of attention correlated consistently with all three of these measures. The Auditory Elevator with Distraction task was also administered. For this subtest participants listened to a beeping elevator presented on audiotape. They were required to count floors in the presence of a distracting tone. This is a measure of selective attention and resistance to distraction. This subtest loaded on an auditory-verbal working memory factor consisting of the PASAT and Backward Digit Span of the WAIS-R. Working memory can be described as the active maintenance and manipulation of information. They were also administered the Auditory Elevator Subtest (without distraction). This task was administered to ensure appropriateness of TEA norms and was not considered in the data analysis. The use of these subtests provided estimates of improvements in the areas of speed of processing, sustained, selective, and more complex attention involving resistance to distraction and working memory processes.

In addition, participants completed two versions of a short computerized working memory task (Kerns, 1997; Owens, Morris, Sahakian, Polkey & Robbin, 1996). They were presented with a number of boxes and words on a computer screen. They were required to locate a number of symbols hidden beneath the words or boxes. This involved remembering where the boxes on the screen that had already been selected were located (spatial memory) and which words they had already chosen (verbal memory). Location of the symbols was randomly determined by the computer program.

Self-report Measures

To address the issue of generalizability to daily living, an attention rating scale was filled out by all participants. A recent study examining the efficacy of memory notebook training found daily charting by patients and significant others of memory failures to be the most sensitive indicator of improvement (Schmitter-Edgecombe et al, 1995). An adaptation of Ponsford and Kinsella's Rating Scale of Attentional Behavior (1991) was used. Participants were asked to fill out the scale for seven days in between each test session and to hand it in when they arrived for biweekly testing. Whenever possible, a significant other also filled out the rating scale. The purpose of this scale was to ascertain if the intervention made any impact on the client's daily life from the perspective of the client and family member and/or significant other. There are drawbacks with using patient self-report and significant other report in assessing the impact of injury on daily functioning. It has been suggested that patient report may have limited reliability (Bennet-Levy & Powell, 1980, cited in Ponsford & Kinsella, 1991). This may be due to several factors such as cognitive limitations in filling out the questionnaires, or limited insight. Ratings made by others may also have limited reliability due to factors such as different levels of familiarity with the patient or variable caregiver level of awareness of the patient's difficulties. Reportedly, levels of fatigue and stress, personality type of the relative, and the amount of time post-injury have all been found to affect the accuracy of the relatives' report (see Fleming et al, 1996 for a review). Daily ratings of attention behavior should provide for more accurate reporting than is obtained when participants and/or caregivers fill out questionnaires retrospectively.

Comparison of differences between participant and significant other ratings also provide a measure of the subject's level of awareness before and after the interventions.

In addition, a very brief questionnaire adapted from the Self-Efficacy Scale (Scherer, Maddux, Mercandante, Prentice-Dunn, Jacobs & Rogers, 1982) was administered. This scale measures generalized self-efficacy expectations dependent on past experiences and on tendencies to attribute success to skill as opposed to chance. The Self-Efficacy Scale was developed with the intent that it may be used as an index of progress in therapy. The scale has been shown to be internally consistent and construct validity has been established. High scorers on the scale were found to be more likely to be employed; high scores also correlated positively with educational level and military rank, demonstrating some evidence of criterion validity. Five items were included in the modified version that queried self-efficacy beliefs related specifically to attention. During the baseline phase this rating scale was administered three times. This was done to assess the stability of the trait being measured. There is no test-retest data available for the rating scale; therefore to be considered meaningful, any change observed during treatment must be larger than the difference observed between the administrations of the scales during the baseline phase. There were nine administrations of the self-efficacy scale in total.

Participants completed the Mood Survery (MS) (Underwood & Froming, 1980; cited in Corcoran & Fisher, 1987). This is a short (18 item), self-report measure of mood (i.e., happy and sad states). It has two primary subscales: level of mood and reactivity to situations. Test-retest reliability for this scale has been reported to be quite good ($r = .80$ and .85). This scale was used to track participants' affective state throughout the rehabilitation process. The MS was administered once during baseline and at the end of each six week phase for a total of three administrations per participant. The Post-Concussive Checklist (Ruffalo, 2000) was completed at the end of the baseline and rehabilitation phases of the study to provide additional information regarding reported symptomatology.

To account for the possibility that change on the self-report measures may not reflect real change but may, in fact, be due to demand characteristics of the situation (i.e., the "halo" effect), an additional measure was given. Participants and significant other (where possible) completed the Verbal Aggressiveness Scale (VAS) (Infante and Wigley, 1986, cited in Corcoran and Fischer, 1987). This scale has good test-retest reliability r = .82 and has been shown to be internally consistent. It is a short self-report measure assessing verbal aggressiveness that is similar in format to the other self-report measures administered. The items are similar to those on the other questionnaires because it asks questions pertaining to daily life experiences in communication with others, and therefore it did not appear odd or out of place to the participants when they were asked to complete it. Because communication skills were not being targeted in the current interventions, it was not expected that scores on this measure should change significantly. Therefore, change on the dependent measures in the context of no change on the VAS would argue for a real effect on the rating scales of attention and self-efficacy. The VAS was administered once during baseline and at the end of each six week phase for a total of three administrations per participant. A smaller number of administrations was felt to be adequate because scores on this measure are not an experimental variable of interest.

Neurophysiological Measures

Event related potentials (ERPs) were recorded three times during the baseline phase and once after each rehabilitation phase for a total of five recordings per participant. Brainstem auditory evoked potentials (BAEPs) and checkerboard pattern visual P100 evoked potentials were recorded during the first test session only. This was done to ensure that participants were free from hearing or visual difficulties that could account for any abnormalities noted in later component ERPs which are the variables of interest.

For recording of ERPs, participants engaged in a visual and an auditory oddball task (detecting targets in a sequence of standard stimuli). For the auditory task they listened to a series of tone beeps presented binaurally through earphones and were required to count the number of targets (designated as the higher tone). Standard or non-target tones were 2000 Hz and targets were 1000 Hz. Both tones were presented at an 80 dB level. Targets were presented 15% of the time ($p=.15$) and non-targets were presented 85% of the time ($p=.85$). This task is believed to tap working memory and attention processes. For the visual task, participants were presented with blue triangles (non-targets, $p=.85$) and blue circles (targets, $p=.15$) on a computer monitor. They were required to press a button whenever a blue circle appeared on the screen. Reaction times were recorded for this task.

ERP Recording

Electrodes were placed on the scalp for 3 response sites (FZ, PZ, CZ - International 10-20 System). These sites are located on the midline and cover the frontal to parietal area.

An electrode cap was used. Electrodes placed on the mastoid served as references. Electrode impedance was kept below ten KΩ. ERPs were recorded using a Bio-Logic Brain Atlas (Bio-Logic Systems). The signal was amplified 50 000 times and filtered with a 60 Hz notch filter with a band pass of 1-30 Hz. Sampling rate was 200 Hz from 100 msec prior to stimulus onset to 924 msec post-stimulus. An automatic artifact rejection system was used to reject trials contaminated with eye blinks, eye movements or excessive muscular activity.

ERP Data Analysis

Waveforms were averaged by the Bio-Logic Brain Atlas system. 30 single sweep waveforms were used to create an average waveform for each task. ERP component wave forms were determined through visual inspection. The most prominent peak occurring for all three electrode sites after the N1-P2-N2 complex was chosen as the P300. Peak amplitude was measured with respect to the mean of the 100 msec pre-stimulus baseline. Latency was measured with respect to stimulus onset and was defined as the time point of maximum positive amplitude.

CASE ANALYSES AND RESULTS

The following section will investigate the hypotheses put forth in the introduction. Data is presented from general to specific. That is, overall support for the hypotheses will be discussed first, together with a reiteration of hypotheses advanced. This will be followed by a comprehensive presentation of all data for each participant. Finally, each dependent variable will be discussed separately.

Single case designs are typically evaluated by visual inspection (i.e., graphing). Kazdin (1984) notes that identifying reliable intervention effects does not require statistical evaluation. A reliable effect can be demonstrated by the replication of intervention and baseline levels of performance over the course of an experiment. Because this study utilized five participants, comparison and replication is possible. Graphing has been carried out as suggested by Krishef (1991). The researcher was blind to the identity and group membership of the participants during the data analysis phase of the study.

Support for Hypotheses

This section will investigate whether the data presented provides support for the hypotheses offered.

Hypothesis #1

It is predicted that neuropsychological test scores will show the most change after participation in the APT only condition.

The data provide support for this hypothesis. Unfortunately, the tasks selected from the Test of Everyday Attention were not as sensitive as expected. They were not challenging enough for a number of participants, who achieved ceiling level performance. The Lottery task was the least sensitive of the three tasks utilized in this study. Two participants did demonstrate improvement on TEA tasks. Participant 2 showed improvement on the Auditory Elevator with Distraction task after APT training and improvement on the Map Search task after participation in the Active Control condition. Because this person received the Active Control condition following APT, it is possible that improvement on the Map Search task was a carry over effect from the APT condition. Participant 5 demonstrated improvement on the Lottery and Map Search tasks after participation in APT (delivered after the Active Control condition). Improvement on the Auditory Elevator Task was noted during the Active Control condition.

The computerized working memory task proved to be a more sensitive measure, with participants working at four levels of difficulty for two tasks. Four of five participants showed some improvement on this task. Of these four participants, three showed improvements after APT only. In fact, one participant (2) demonstrated a decrease in performance when participating in the Active Control condition, after showing improved performance during APT. Participant 1 showed improvement on the working memory task during the Active Control condition. However, she received APT prior to participation in this condition and therefore carry over effects cannot be ruled out. No participant showed improved performance on the working memory task after the Active Control condition without prior APT participation.

Hypothesis #2

It is predicted that neurophysiological variables (P300 and N200) will show the most change after participation in the pure attention training condition (APT).

Data provide strong support for this hypothesis. In fact, ERP measures were more sensitive than the neuropsychological tests employed (TEA) as all participants showed at least one consistent change in either amplitude or latency of the P300 or N200 components. All participants showed changes in ERP components after participation in APT regardless of order of exposure to therapeutic condition. Only one participant showed an ERP change after participation in the Active Control condition only.

Hypothesis 2a: A decrease in latency of the P300 and N200 components will be observed after participation in APT. In addition, a decrease in the negativity of the N200 is also predicted. It is predicted that P300 amplitude will also show change but specific hypotheses about directionality of this change are not offered.

Generally, most ERP changes observed were in the expected direction. A decrease in P300 latency was observed for two of five participants for the auditory task. A decrease in N200 latency was observed for one participant for the auditory task. A decrease in negativity of the N200 was observed for three of five participants. Four participants showed increased amplitude of the P300 (3 for the visual task, 1 for the auditory task). A decrease in P300 amplitude was observed for two participants for the visual task only. There were more ERP changes noted for the visual task than for the auditory task.

Hypothesis #3

It is also predicted that self-efficacy beliefs and number of reported attentional problems will change as a function of participation in the rehabilitation program.

Data provided only weak support for these hypotheses. Two participants showed increased feelings of self-efficacy, as indicated by higher scores on a self-report measure of self-efficacy. For one participant, this change was restricted to self-efficacy beliefs for attention specific behaviors. Both participants received APT followed by the Active Control condition. Increased scores were noted during APT and maintained through the Active Control phase of the study.

Two participants showed decreased reporting of attention problems. For one participant, this coincided with participation in the Active Control condition. For the other participant, reduced reporting of attention problems occurred during the APT condition. Interestingly, these two participants could easily be characterized as the "most positive" and "least positive" members of the study, in terms of attitude toward their difficulties. The highly positive individual showed less reporting of difficulties during the Active Control condition and the highly negative individual showed reduced reporting during APT. In fact, this individual showed increased reporting of attention problems during the Active Control condition. Interpretation of this data for other participants was limited by variability, failure to remember to record data, and missing data.

Summary of Findings by Participant

Findings for Participants 1 and 2

These two participants comprised Group One and received individually administered APT followed by participation in the Active Control group.

Participant 1

This Participant demonstrated a number of changes following participation in individually administered APT. Evoked potential changes included increased P300 amplitude and decreased negativity of the N200 component for the auditory task. For the visual task, this participant demonstrated a reduction in P300 amplitude and latency. All of these changes were more pronounced after participation in the Active Control condition.

No significant improvements were observed on TEA subtests. Participant 1 achieved ceiling performance for two of the three tasks and showed too much variability in baseline levels for the Map Search task to attribute improvement to the rehabilitation tasks. Participant 1 demonstrated decreased error rates for the two most difficult conditions of the working memory task (8 and 12 words). This difference was observed during the Active Control condition. This Participant demonstrated increased ERP latencies and increased errors on neuropsychological tasks for the third baseline session. This contributed to considerable variability in her data. This is an interesting finding in light of the assertion that individuals with TBI show more variability than controls, and that this is sometimes what differentiates the two groups (Segalowitz, Dywan, & Unsal, 1997).

In terms of self-report measures, this participant showed an increase in feelings of self-efficacy specific to attention related items during both APT and the Active Control condition. She endorsed virtually no problems with attention on the Attention Rating Scale. However, ratings made by her husband indicated that he observed problems with attention.

Secondary measures were not filled out for every test session by this participant. Initial screening using the Rand Depression Inventory indicated no symptoms of depression. The Mood Survey completed at the first baseline session only also indicated generally positive and stable mood. She completed the Post-Concussive Checklist at pre and post-test only. Her score was quite low indicating minimal symptoms. However, she did show decreased symptom reporting for cognitive symptoms and brain injury related physical symptoms at post-test. Her self-report was compared to her husband's (filled out at pre-test only). The comparison indicated that Participant 1 views herself as less disabled by her injuries than does her husband. This is consistent with findings on the Attention Rating Scale. The Verbal Aggressiveness Scale was administered as a check for "halo effects." This participant completed this scale for the baseline phase and for the APT phase. Her overall score was low, indicating a low level of self-reported verbal aggressiveness. She did demonstrate a lowering of her score on this measure from baseline to the end of the APT phase, however she did not fill out three items which may account for the lower score. Her husband filled out the VAS-other form for the baseline session. His report indicated more behaviors that could be described as verbally aggressive. This is consistent with his reporting of more problems with attention on the attention rating scale and more symptoms on the post-concussive checklist.

Participant 1 is retired. She spends a large percentage of her daily time engaged in rehabilitative activities such as swimming and physical therapy in addition to participation in this study. She continued to pursue her rehabilitation and hobbies after the completion of the study.

Participant 2

Participant 2 also demonstrated a number of evoked potential changes after participation in individually administered APT. For the auditory task he showed decrease P300 latency, decreased negativity of the N200 and increased N200 latency. For the visual task, decreased P300 amplitude was observed. These changes were maintained during participation in the Active Control condition.

This Participant demonstrated consistent improvement on two of three subtests of the TEA. After two weeks of APT training, he achieved ceiling performance for the Auditory Elevator with Distraction task and maintained this for the remainder of the test sessions (3 sessions) before showing a drop of 1 point (to baseline levels) for the last test session (following six weeks of the Active Control condition). For the Map Search task, Participant 2 showed improvement noted most consistently for the last three test sessions (Active Control condition).

For the working memory task, Participant 2 showed an improvement in error rates to ceiling level for the six item word task during the APT condition. This was maintained during the Active Control condition. There was a decrease in error rates for the 12 item word task during APT, however this returned to baseline levels during the Active control condition. Similarly, he showed an improvement in error rates for the 12 item box condition during APT that was also not maintained during the Active Control condition.

Participant 2 showed an increase in self-efficacy scores (general and for attention specific items) during both therapeutic conditions. Baseline recording of attention problems on the Attention Scale was variable so it is difficult to interpret data for this participant on this measure.

Secondary measures were not filled out for the last test session by this participant. Initial screening using the Rand Depression Inventory indicated symptoms of depression. This participant readily admitted to struggling with depressed mood. The Mood Survey completed at the first baseline session indicated generally positive and consistent mood. The MS was also filled out after participation in APT. Level of mood was about the same with some increase in feelings of mood reactivity or changeability. The Post-Concussive Checklist was filled out at pre-test, after APT, and after participation in the Active Control condition for a total of three measures. After participation in APT, this participant showed a decrease in self-reported symptoms in the cognitive, emotional/psychosocial and TBI related physical categories of the PCS. However, Participant 2 showed an increase in self-reported symptomatology for emotional/psychosocial and cognitive symptoms after participation in the Active Control condition. In fact, he reported more symtoms in those two domains than at pre-test. The Verbal Aggressiveness Scale was completed for the baseline phase and for the APT phase. Participant 2's overall score was low, indicating a low level of self-reported verbal aggressiveness. There was virtually no change indicated on the second administration of this measure.

Participant 2 successfully completed a college course during participation in the study and was accepted into a program at an out of town college. He left town to attend this program shortly after study completion. Subjectively, he felt that he was doing much better at the end of the study in terms of speed of thinking and endurance for cognitive activities.

<u>Findings for Participant 3</u>

This Participant was unable to attend the Active Control condition due to getting a job. Therefore, he underwent an extended baseline (six sessions) and participation in the APT condition only.

Participant 3 showed the least amount of change of all the individuals who participated in this study. The only evoked potential change noted was an increase in P300 amplitude for the visual task. He achieved ceiling level performance during baseline on one of the TEA tasks and showed no consistent improvements on the other TEA subtests. Participant 3 achieved ceiling level performance for the easier conditions of the working memory task and did not demonstrate any consistent improvement on the more difficult tasks (8 and 12 items). Similarly, there was no consistent or significant change on the brief self-efficacy scale or on the attention rating scale.

Secondary measures were not filled out for every test session by this participant. Initial screening using the Rand Depression Inventory indicated minimal symptoms of depression. The Mood Survey was completed only at the last test session, at the conclusion of the study. Mood was reported to be generally positive. Due to administration error, data was only available for the last test session for the Post-

Concussive Checklist so comparison of pre and post-test ratings of post-concussive symptoms was not possible. However, Participant 3's mother filled out the Post-Concussive Checklist - other form. Comparison of her ratings to his shows that he views himself as more symptomatic than does his mother. The Verbal Aggressiveness Scale was completed for all three phases of the study and no significant change was noted. His overall score was low, indicating a low level of self-reported verbal aggressiveness.

This participant was unemployed at the beginning of the study but obtained work in a restaurant as a host/bus boy mid-way through the study. At the end of the study he was feeling very positive about his job and was hoping to move into a position as a waiter.

Findings for Participants 4 and 5

These participants comprised Group Two and participated in the Active Control Group followed by group administration of APT. Due to unforeseen circumstances, the last test session for participants 3, 4 and 5 occurred two weeks after the conclusion of the study.

Participant 4

Similar to Participant 3, Participant 4 showed very few changes. He showed only one evoked potential change after participation in APT: an increase in P300 amplitude for the visual task. This change was not noted after participation in the Active Control condition. Ceiling level performance was achieved for two of three TEA tasks. There was no consistent improvement for the third TEA task. There was decreased error rates observed for some conditions of the working memory task (8 and 12 items) during the APT condition.

This participant showed no change in self-efficacy scores. Self-reported attention problems were reduced during the Active Control condition. There were only three data points for the APT condition.

Secondary measures were not filled out for every test session by this participant. Initial screening using the Rand Depression Inventory indicated minimal symptoms of depression. The Mood Survey was completed only at the first baseline test session. Mood was reported to be generally positive and stable. The Post-Concussive Checklist was not completed. The Verbal Aggressiveness Scale was completed for all but the last phase of the study and no significant change was noted. His overall score was low, indicating a low level of self-reported verbal aggressiveness.

Participant 4 was living in a supported facility upon entry to the study. During the study duration, arrangements were made for him to move into his own apartment with a roommate. This took place shortly after the completion of the study. This participant was not gainfully employed but participated in daily programming though an acquired brain injury program. He also engaged in odd jobs to earn some money.

Participant 5

Participant 5 showed a number of evoked potential changes. For the auditory task, he demonstrated decreased P300 latency after participation in APT and decreased N200 latency after participation in both conditions. For the visual task, he demonstrated increased P300 amplitude and deceased N200 negativity after participation in APT only.

This participant also showed changes on two TEA subtests during the APT condition. Improvement on the Auditory Elevator with Distraction task was also noted during the Active Control condition. There was some lowering of scores noted for the last test session (two weeks after study termination). Participant 5 showed a decrease in reaction time for the working memory task (6, 8 items) for both study conditions, with no corresponding change in error rates. A drop in error rates was only observed for the 12 item word task. The error reduction was observed for the APT condition only.

There was no change in ratings of self-efficacy. However, Participant 5 showed decreased reporting of attention problems during the APT phase. During the Active Control phase, this participant reported the maximum number of attention problems. This is an interesting finding suggesting that this person was very tuned in to his problems during the Active Control or psychotherapeutic condition.

Secondary measures were not filled out for every test session by this participant. Initial screening using the Rand Depression Inventory indicated significant symptoms of depression. This participant was very vocal regarding his distress and his affect during sessions was often labile and angry. The Mood Survey was completed only at the first baseline test session. Mood was reported to be generally negative with low mood changeablity. Participant 5's score on the Post-Concussive Checklist was very high, indicating high endorsement of post-concussive symptoms. At post-test, there was evidence of decreased reporting of cognitive and TBI related physical symptomatology. There was no reduction in emotional/psychosocial symptomatology. The Verbal Aggressiveness Scale was completed for the first (baseline) and last phase of the study (after conclusion) and no significant change was noted. Interestingly, Participant 5 achieved a very low overall score, indicating a low level of self-reported verbal aggressiveness. However, experience of this man in the intervention groups was that he was, by far, the most verbally aggressive participant in the study.

Participant 5 was unemployed and living in an apartment with a roommate at the beginning of the study. His life circumstances were unchanged at the end of the study. Summary data for all participants are presented in Table 2 and Table 3.

Table 2.

Summary of Changes on Neuropsychological Measures and Self-Ratings for Each Participant

	TEA	Working Memory	Self-Efficacy	Attention Ratings
1	No*	Yes	Yes	No
2	Yes	Yes	Yes	No
3	No*	No	No	No
4	No	Yes	No	Yes
5	Yes	Yes	No	Yes

* ceiling effects observed

Table 3.

Summary of ERP Changes for Each Participant

	Auditory Task		Visual Task	
1	incr. P3 amp	decr. N2 negativity	decr. P3 amp	decr. P3 lat
2	decr. P3 lat incr. N2 lat	decr. N2 negativity	decr. P3 amp	
3	No changes		incr. P3 amp	
4	No changes		incr. P3 amp	
5	decr. P3 lat	decr. N2 lat	incr. P3 amp	decr. N2 negativity

Note. Abbreviations are as follows: lat = latency, decr. = decrease, incr. = increase, amp = amplitude

Analysis of Neurophysiological Data

Evoked potential data was examined by graphing latency and amplitude values for the P300 and N200 components. Data was graphed for each site individually (FZ, CZ, PZ). It was felt that inspection of amplitude and latency values for individual sites would be more sensitive than collapsing these values across all three sites because site differences in amplitude, latency and the relationship between amplitude and latency have been reported (Ravden & Polich, 1999). For each participant, the site demonstrating the strongest effect is illustrated graphically. Waveforms were examined for target and non-target stimuli. There was no evidence of difficulty in discriminating between target and non-target data as evidenced by no participants demonstrating abnormalities in their non-target evoked potentials (such as the presence of a large P300 waveform to non-target stimuli).

Participant 1

Auditory Task:

This Participant demonstrated an increase in amplitude of the P300 component of the auditory evoked potential after APT. The observed increased amplitude continued after the Active Control condition. Baseline amplitudes for the P300 were 5.2 mV, 1.7 mV, 1.82 mV. Amplitude after APT only was 6.61 mV and after APT and the active control condition was 7.72 mV (see Figure 1). P300 latency also demonstrated a decrease; however, it is difficult to interpret this data due to an unstable baseline.

Participant 1 demonstrated decreased negativity of the N200 for the auditory task after APT that continued after participation in the Active Control condition. Baseline amplitudes for the N2 were -1.69 mV, -2.11 mV, -2.0 mV. Amplitude after APT only was -1.0 mV and after APT and the active control condition was 1.54 mV (see Figure 2). Baseline latencies for N2 were not stable.

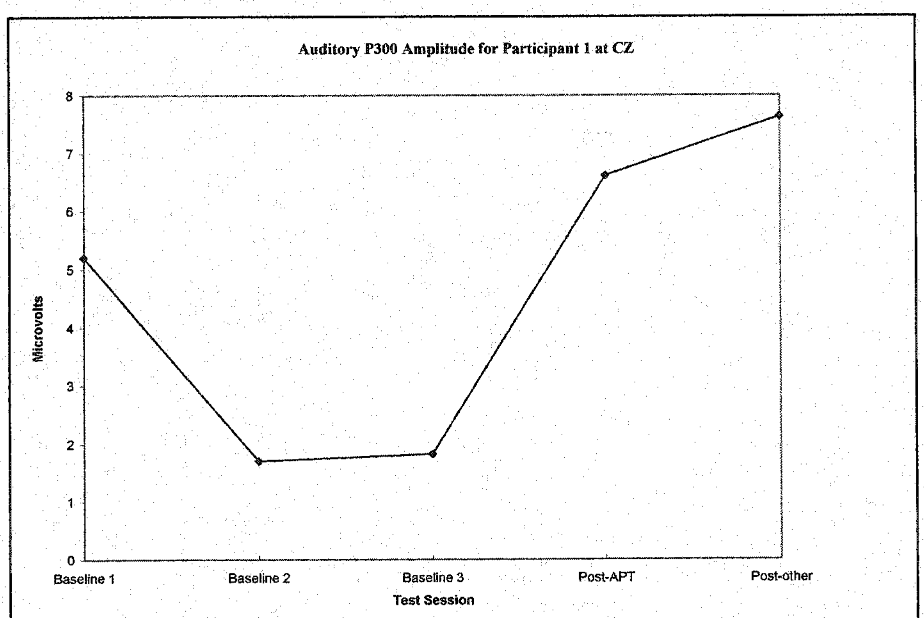

Figure 1. P300 amplitude values (auditory task) for Participant 1 for each test session, recorded at site CZ.

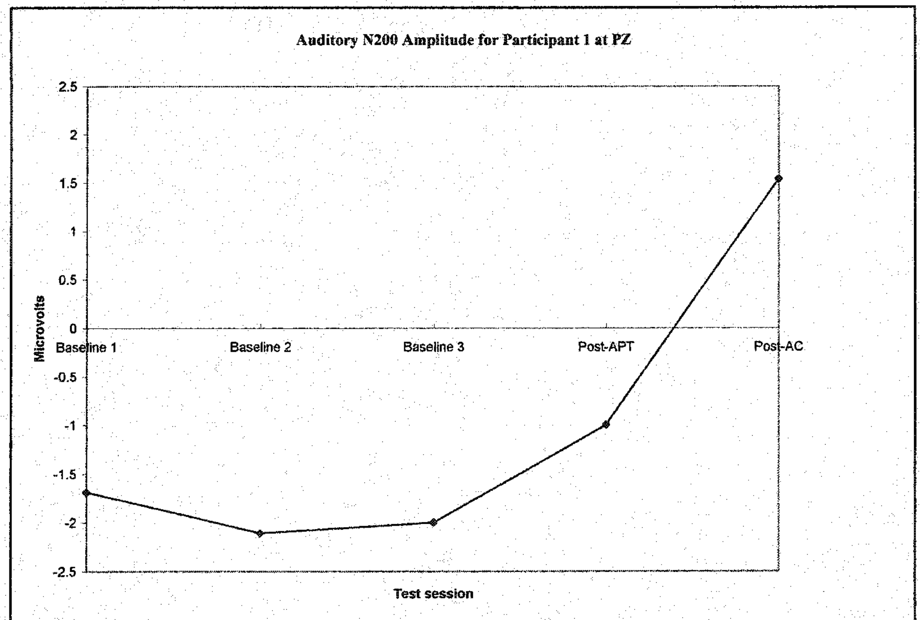

Figure 2. N200 amplitude values (auditory task) for Participant 1 for each test session, recorded at site PZ.

Visual Task

Participant 1 did not show corresponding changes for the visual task in the P300 or N200 components, however, some changes were observed. A decrease in P3 amplitude was observed for this task and there was a decrease in P300 latency. Baseline amplitudes for the P300 were 10.77 mV, 18.59 mV, 11.68 mV. Amplitude after APT only was 7.59 mV and after APT and the Active Control condition was 4.25 mV (see Figure 3). Latencies for baseline measurements were 436 msec, 424 msec, 604 msec. Latency after APT only was 316 msec and after the Active Control condition was 300 msec (see Figure 4). Reaction time (RT) for this task also showed a decrease from baseline. Baseline reaction times were 366.5 msec, 358 msec, 391 msec. After APT, RT for the visual task was 341 msec. RT was 341.5 after the active control condition. N2 data could not be interpreted for this task because of unstable baseline data.

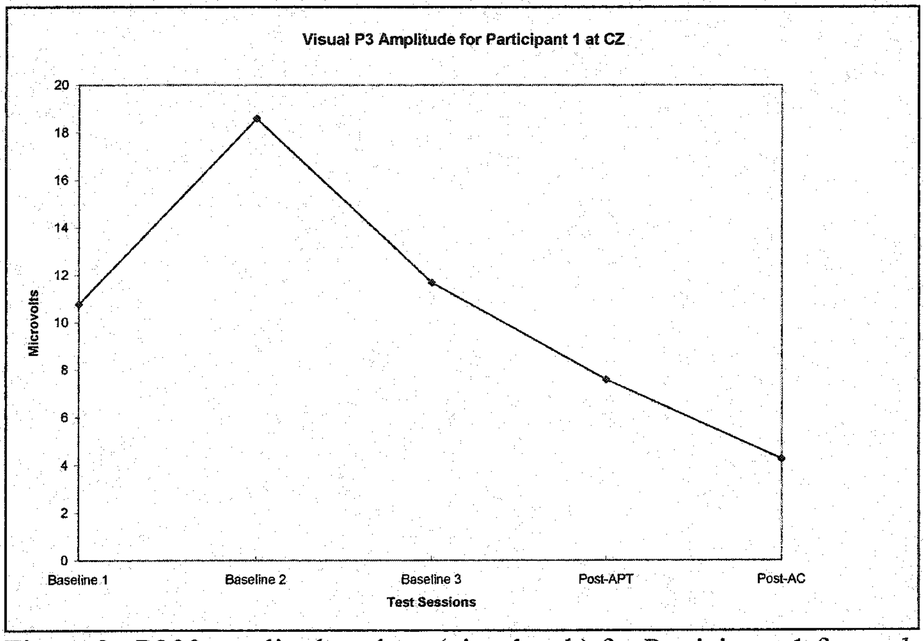

Figure 3. P300 amplitude values (visual task) for Participant 1 for each test session, recorded at site CZ.

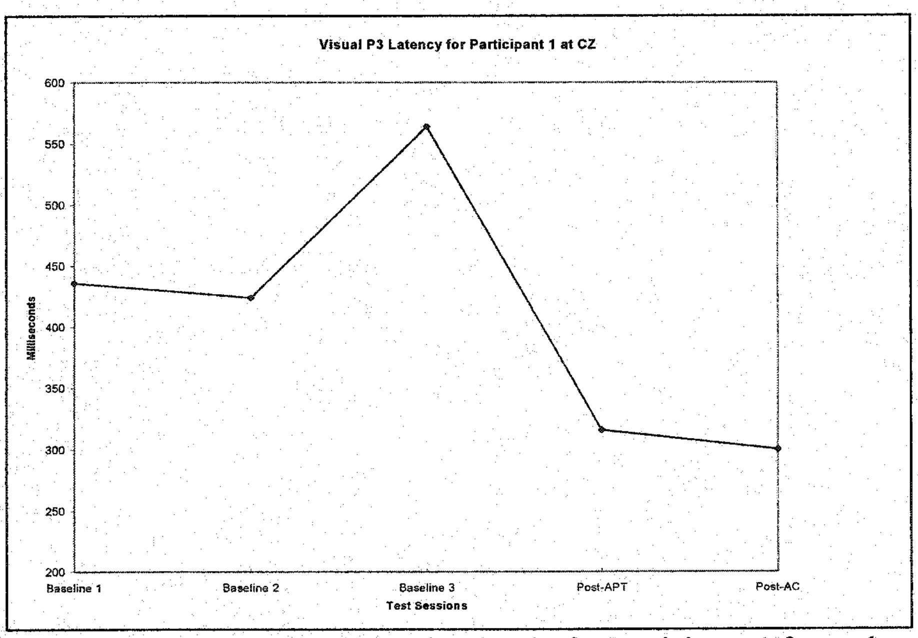

Figure 4. P300 latency values (visual task) for Participant 1 for each test session, recorded at site CZ.

Participant 2

Auditory Task:

This participant showed three evoked potential changes for the auditory task after participation in APT. There was a decrease in P300 latency accompanied by an decrease in negativity of the N200 and an increase in N200 latency following APT. There was no change in amplitude of the P300 evoked potential. Baseline measures for latency of the P300 were 348 msec, 344 msec, 348 msec. Latency after participation in APT was 340 msec; after participation in the Active Control condition latency was 332 msec (see Figure 5).

Baseline amplitudes for the N200 were –2.91 mV, -3.55 mV, -3.36 mV. After participation in APT, N200 amplitude was .47 mV. After participation in the Active control condition, amplitude was -.3 mV (see Figure 6). Baseline latencies of the N200 were 256 msec, 216 msec, 220 msec. After participation in APT, latency was 288 msec, and was 280 msec after participation in the Active Control condition (see Figure 7).

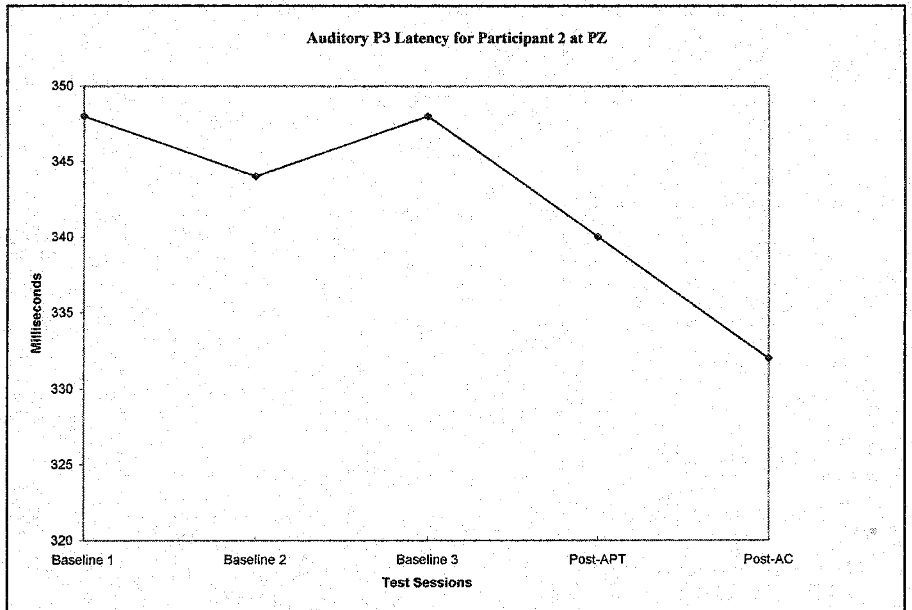

Figure 5. P300 latency (auditory task) for Participant 2 for each test session, recorded at site PZ

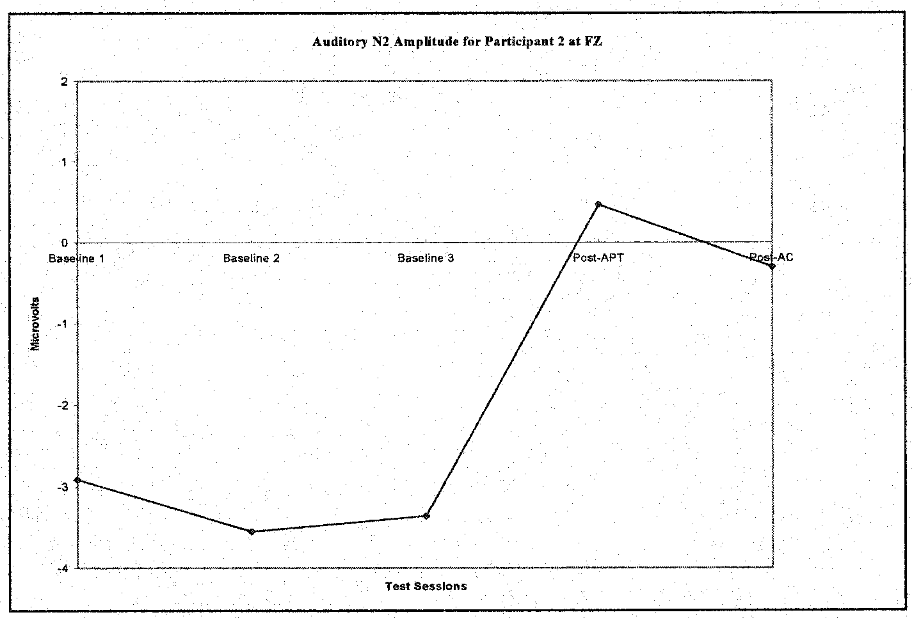

Figure 6. N2 Amplitude (auditory task) for Participant 2 for each test session, recorded at site FZ

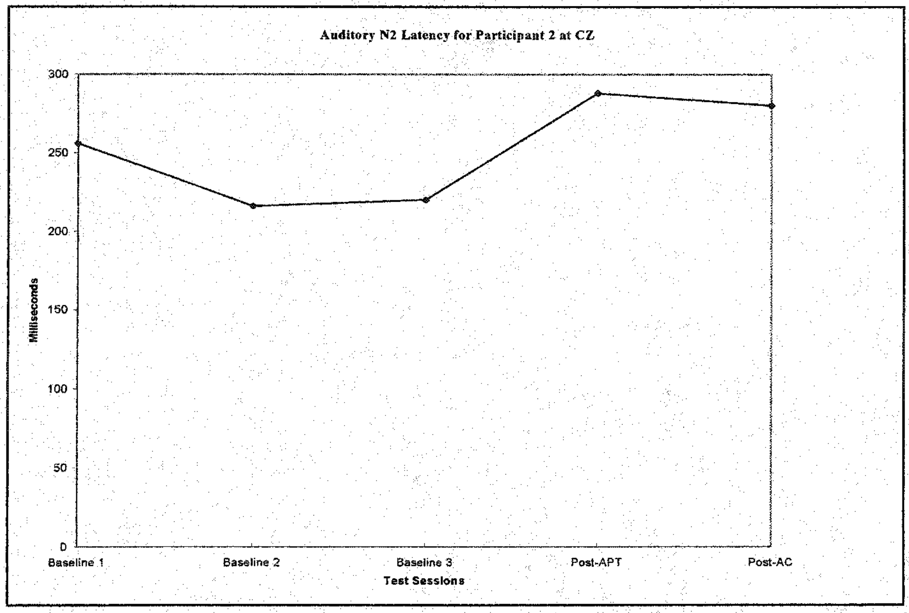

Figure 7. N2 latency (auditory task) for Participant 2 for each test session, recorded at site CZ

Visual Task:

Participant 2 showed decreased P300 amplitude after participation in APT. Baseline amplitudes for the P300 were 9.34 mV, 10.49 mV, 9.99 mV. After participation in APT, P300 amplitude was 7.23 mV. After participation in the Active control condition, amplitude was 7.36 mV (see Figure 8). There was variability in baseline data for P300 latency for the visual task. There were no observed changes in the N200 component.

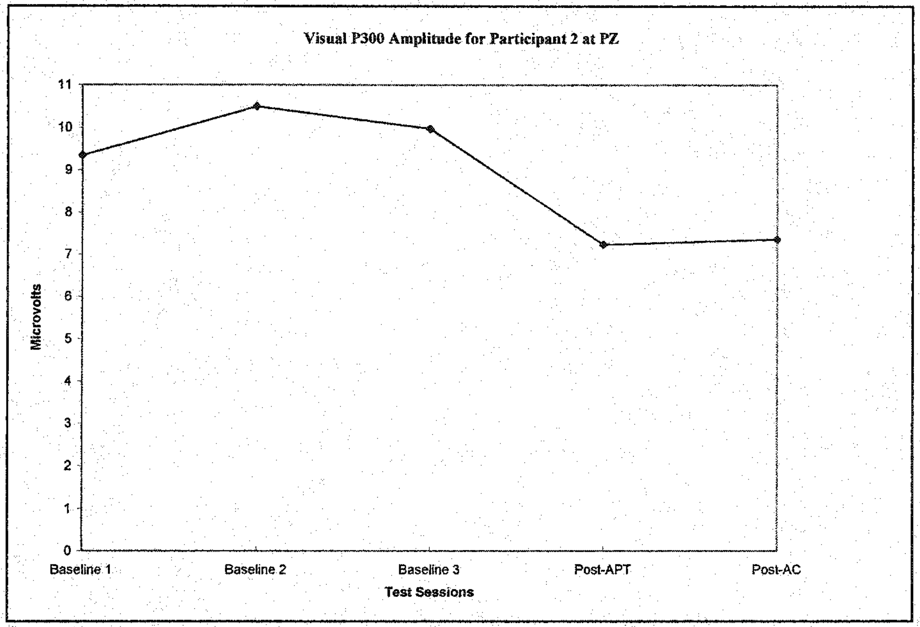

Figure 8. P300 amplitude (visual task) for Participant 2 for each test session, recorded at site PZ

Participant 3

Auditory Task:

This participant showed no changes in ERP measures for the auditory task.

Visual Task

This participant missed one session and data for session #2 was discarded due to a poor quality record. Therefore, only three data points were available for graphing. This participant was seen for four baseline sessions and participated only in the APT only condition. He showed an increase in P300 amplitude for the visual task after participating in APT. Amplitude of the P300 was 3.21 mV for the first baseline session. Amplitude was 14.86 mV for the fourth baseline session and was 20.53 mV after participation in six weeks of APT (see Figure 9).

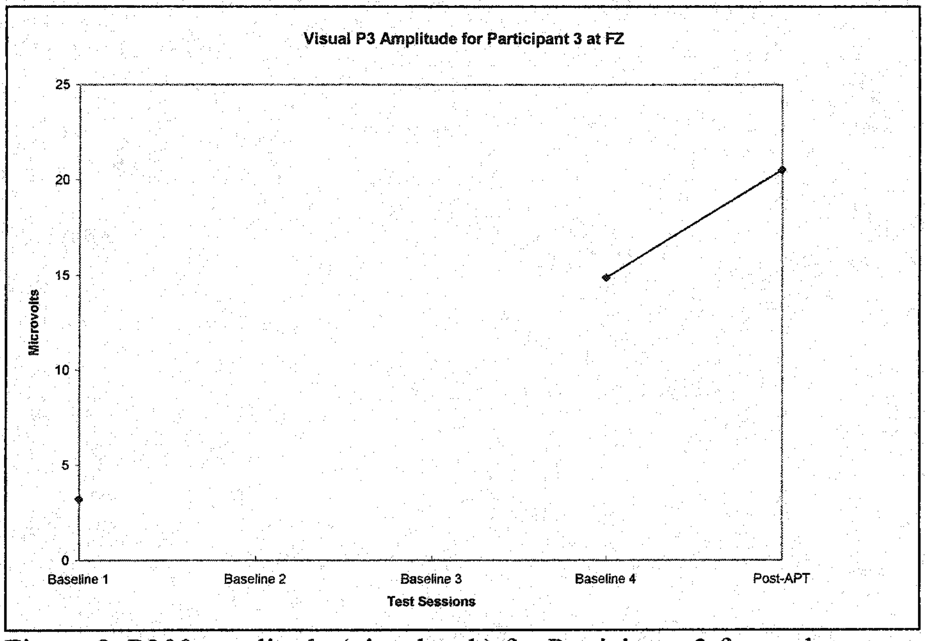

Figure 9. P300 amplitude (visual task) for Participant 3 for each test session, recorded at site FZ

Participant 4

Auditory Task:

This participant showed no changes in either the P300 or the N200 components after participation in either condition for the auditory task.

Visual Task:

Participant 4 showed an increase in P300 amplitude following APT. Only two baseline measurements were available for this participant due to a poor quality recording. Baseline measures for P300 amplitude were 6.97 mV and 9.25 mV. After participation in the Active Control condition, amplitude was 8.07 mV. After APT amplitude was 20.53 mV (see Figure 10). P300 latency was variable.

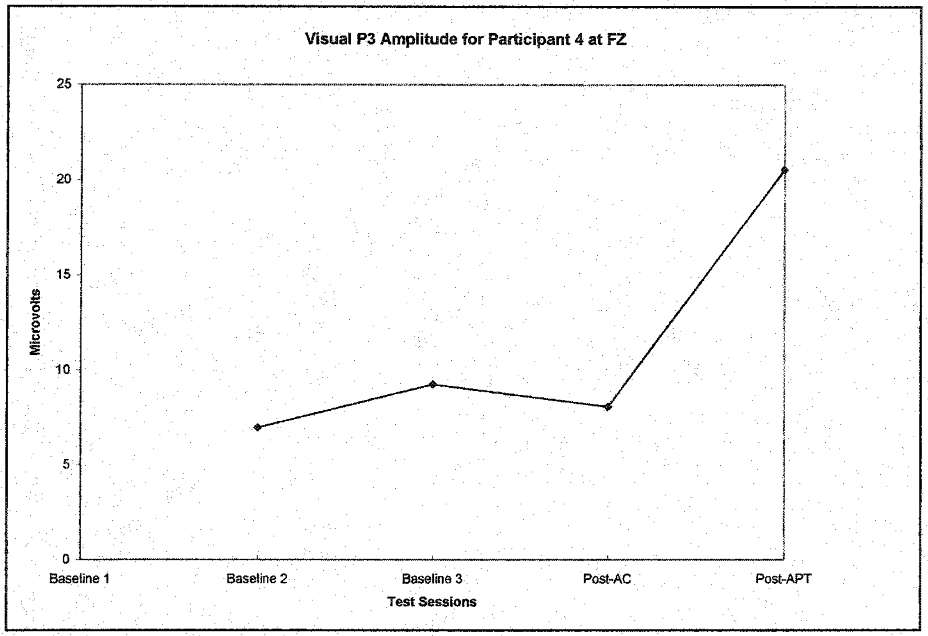

Figure 10. P300 amplitude (visual task) for Participant 4 for each test session, recorded at site FZ

Participant 5

Auditory Task

Participant 5 showed decreased latency of both the P300 and the N200 components for the auditory task. This participant missed one baseline session; therefore, there are only two data points for baseline data. Baseline measures for latency of the P300 were 616 msec and 392 msec. After participation in the Active Control condition, P3 latency was 368 msec. After APT, latency was 264 msec (see Figure 11). Baseline measures for latency of the N200 were 408 msec, 252 msec. After the active control condition, latency was 204 msec. After APT it was 200 msec (see Figure 12). No changes in amplitude of either component were observed.

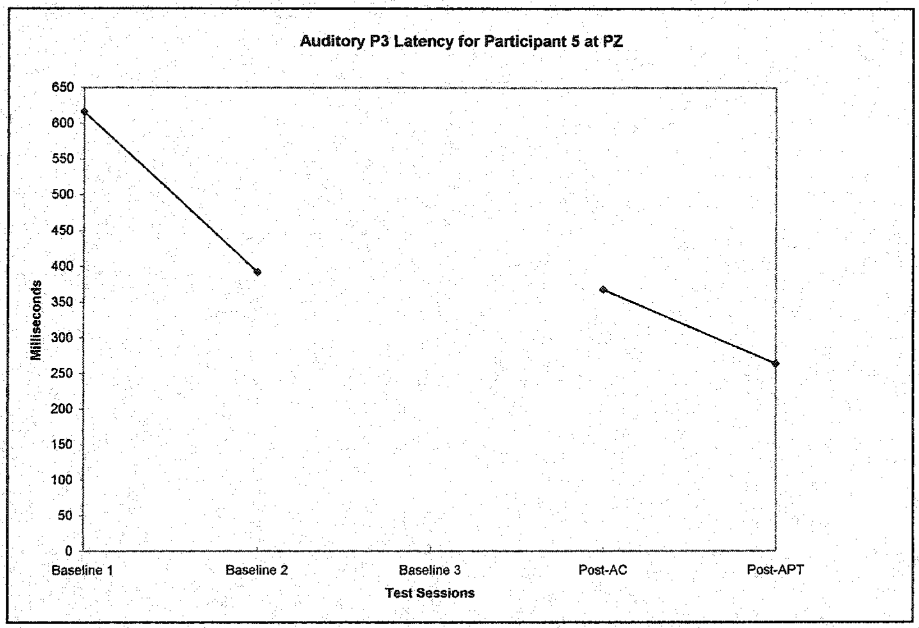

Figure 11. P300 latency (auditory task) for Participant 5 for each test session, recorded at site PZ

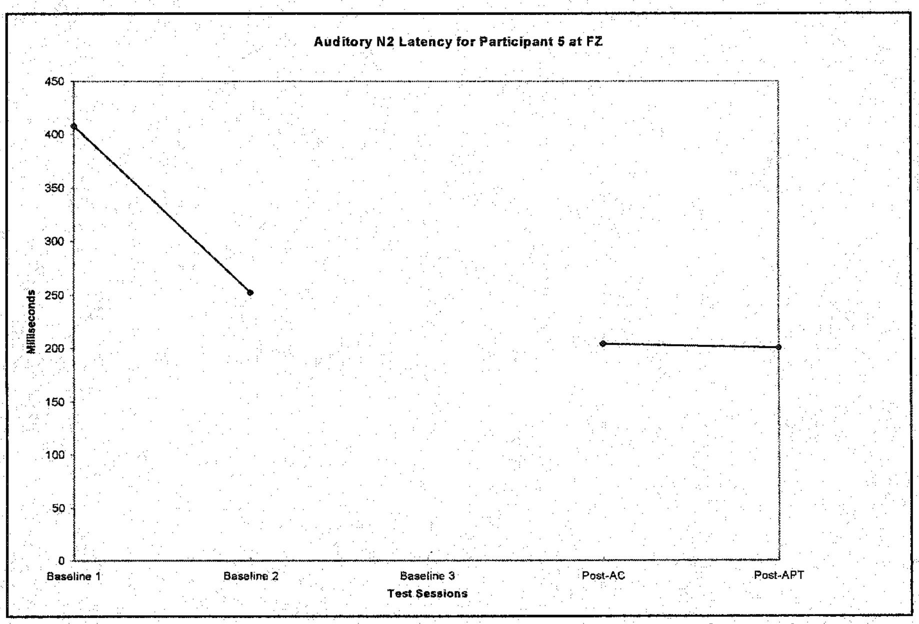

Figure 12. N2 latency (auditory task) for Participant 4 for each test session, recorded at site FZ

Visual Task:

This participant showed an increase in P300 amplitude and a decrease in negativity of the N200 for the visual task with no corresponding changes in latency of either component. Baseline measures for P300 amplitude were 4.82 mV, 7.04 mV. After the Active Control condition, amplitude was 3.83 mV and after APT amplitude was 11.27 mV (see Figure 13). Baseline amplitude measures for the N200 were –4.82 mV and –6.33 mV. After participation in the Active Control condition, amplitude was –6.32 mV. After APT participation, amplitude was –1.78 mV (see Figure 14).

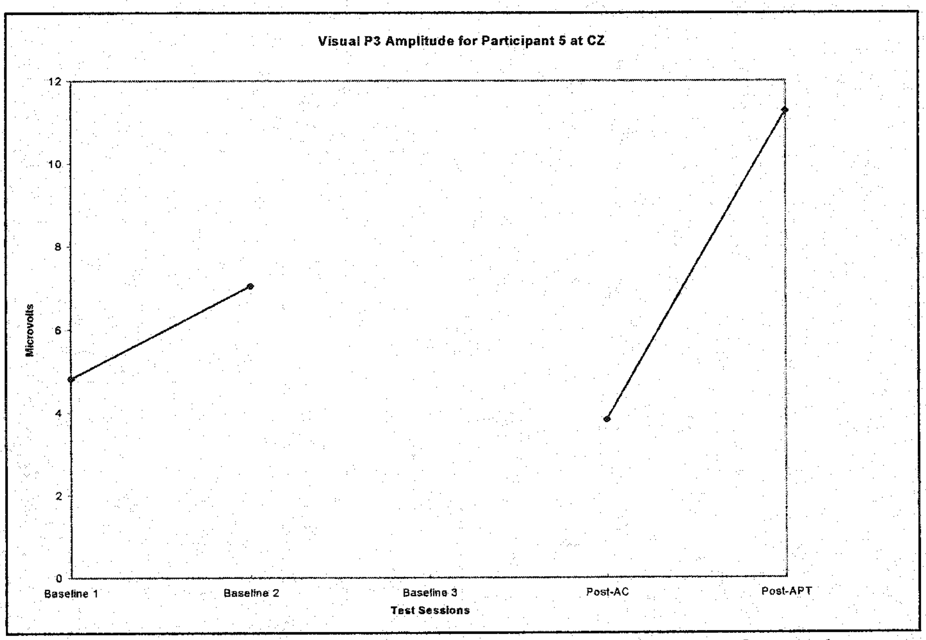

Figure 13. P300 amplitude (visual task) for Participant 5 for each test session, recorded at site CZ

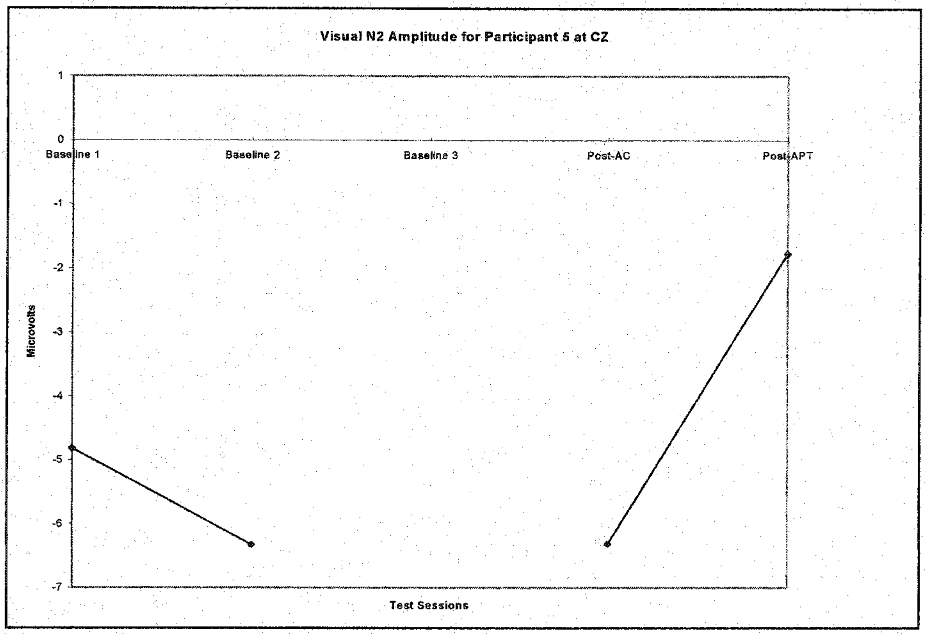

Figure 14. N2 amplitude (visual task) for Participant 5 for each test session, recorded at site CZ

Analysis of Neuropsychological Data

This section includes a discussion of performance on the selected subtests of the Test of Everyday Attention, administered at two week intervals. Because this study utilized alternate forms of the TEA, data were graphed as Z scores to account for variability between forms. Performance on the computerized working memory task developed by Owens and colleagues (1996) and modified by Kerns (1997) is also discussed below.

Participant 1

Participant 1 achieved ceiling performance on the Lottery task on the second baseline session and maintained this performance with little variability throughout the duration of the study. This participant had difficulty on the Elevator with Distraction subtest for the first baseline session, obtaining a score 2 standard deviations below the mean. By the third baseline session performance had reached ceiling levels on this task as well, indicating the presence of considerable practice effects for this participant. Participant 1 did show an improvement on the Map Search task, however baseline performance showed considerable variability, so it is difficult to interpret improvement beyond normal variability.

Participant 2

This participant demonstrated considerable variability in performance on the Lottery subtest. His performance ranged from a z score of -2 to +1 (ceiling performance). In terms of raw scores, Participant 2 showed a very stable baseline for the Auditory Elevator with Distraction task. After two weeks of APT training, he achieved ceiling performance and maintained this for the remainder of the test sessions (3 sessions) before showing a drop of 1 point (to baseline levels) for the last test session (following six weeks of the Active Control condition). Graphing of z scores showed a similar pattern of improvement for test sessions 3, 4, and 5 (see Figure 15). For the Map Search task, Participant 2 showed a consistent baseline in terms of z scores with improvement noted most consistently for the last three test sessions (during Active Control) (see Figure 16).

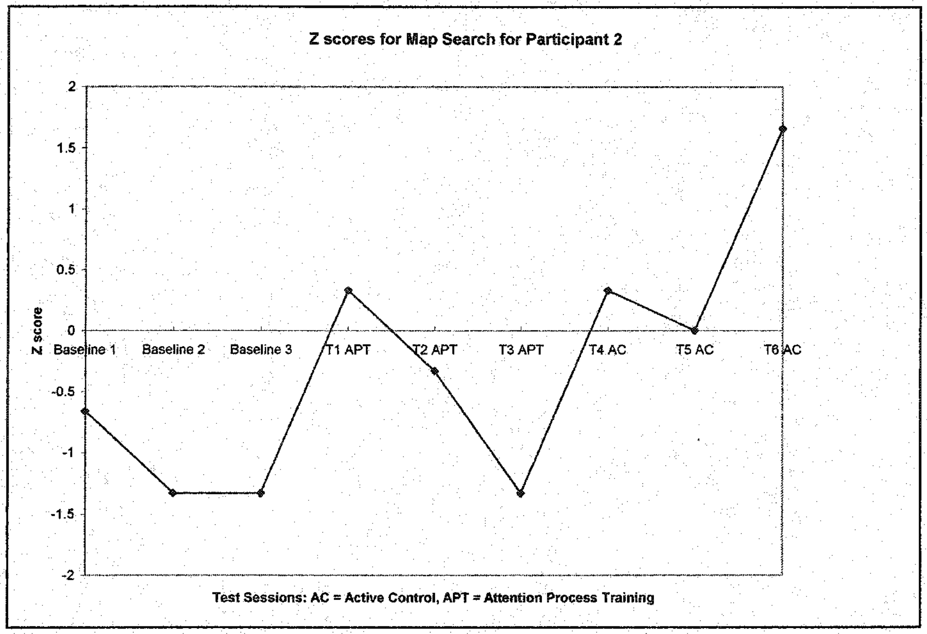

Figure 15. Z scores for the Map Search task for Participant 2 for each test session.

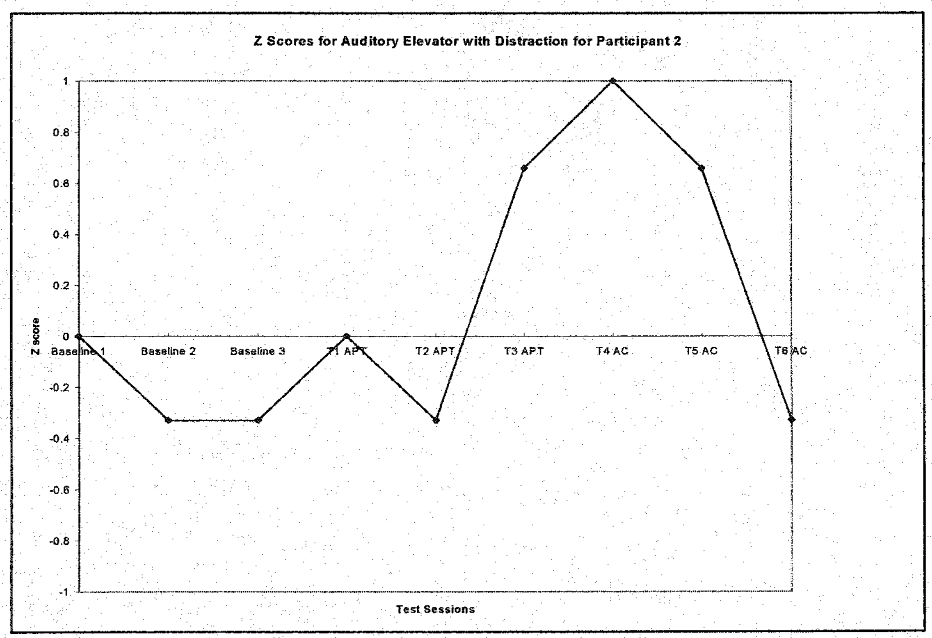

Figure 16. Z scores for the Auditory Elevator with Distraction task for Participant 2 for each test session.

Participant 3

As noted previously, this participant received an extended baseline period and participated only in the APT condition. Similar to Participant 1, he achieved ceiling level performance on the Lottery task during the baseline period. This participant did not demonstrate any improvement on the Auditory Elevator with Distraction task. Performance on this task, although not at ceiling levels, was within the normal range. Similarly, this participant did not demonstrate any consistent improvement on the Map Search task. His scores ranged from a z score of -2.3 to -0.6.

Participant 4

Participant 4 showed variability in performance on the Lottery task. Performance achieved ceiling levels on three of eight test sessions. A similar pattern was observed for performance on the Auditory Elevator with Distraction task. This participant achieved ceiling performance on three of eight test sessions. No consistent improvement was noted for the Map Search task with z scores ranging from -1 to +1.

Participant 5

This participant showed an improvement on the Lottery task during the last three test sessions (during APT). He did not achieve ceiling performance. Mean z score for the baseline period was -1.8. Similarly, mean z score performance for phase 1 (Active control) was -1.77. Mean z score performance for phase 2 (APT) was -.77. Performance in terms of z scores for individual test sessions is shown in Figure 17. This participant also showed an improvement on the Auditory Elevator with Distraction task. This improvement was noted during phase 1 (Active Control condition) and continued during APT with some lowering of scores for the last test session (two weeks post-study) (see Figure 18). Performance for the Map Search task showed considerable variability in terms of z scores. The baseline was stable (z = 0) and improvements and decreases in performance were observed during phase 1 (z = -1.4 to +2). Considerable improvement was noted for the APT phase (z = +3 and +2.6). However there was a drop to z = -.4 for the last test session. This corresponds with the drop in scores also observed for the Auditory Elevator with Distraction task.

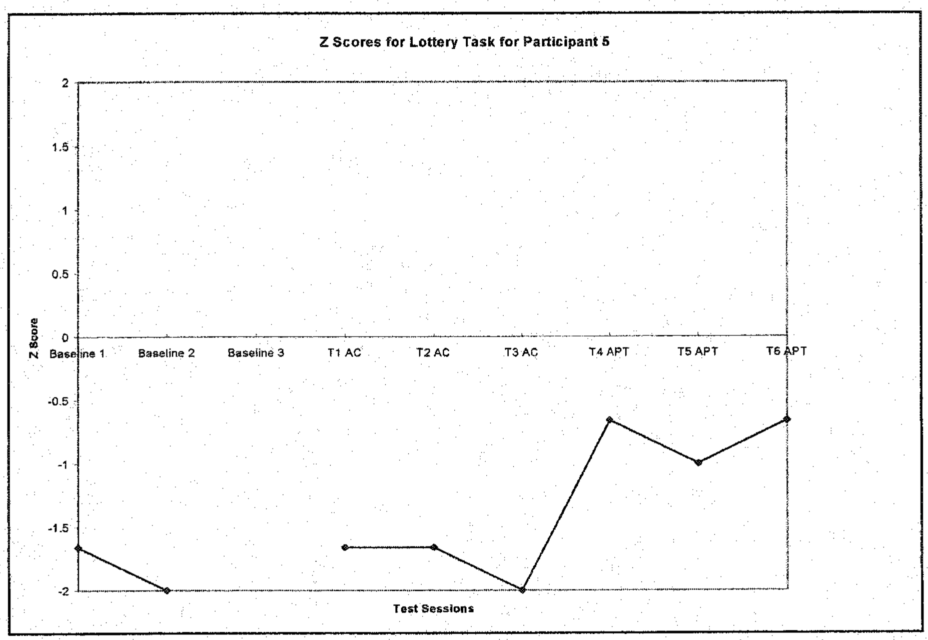

Figure 17. Z scores for the Lottery task for Participant 5 for each test session.

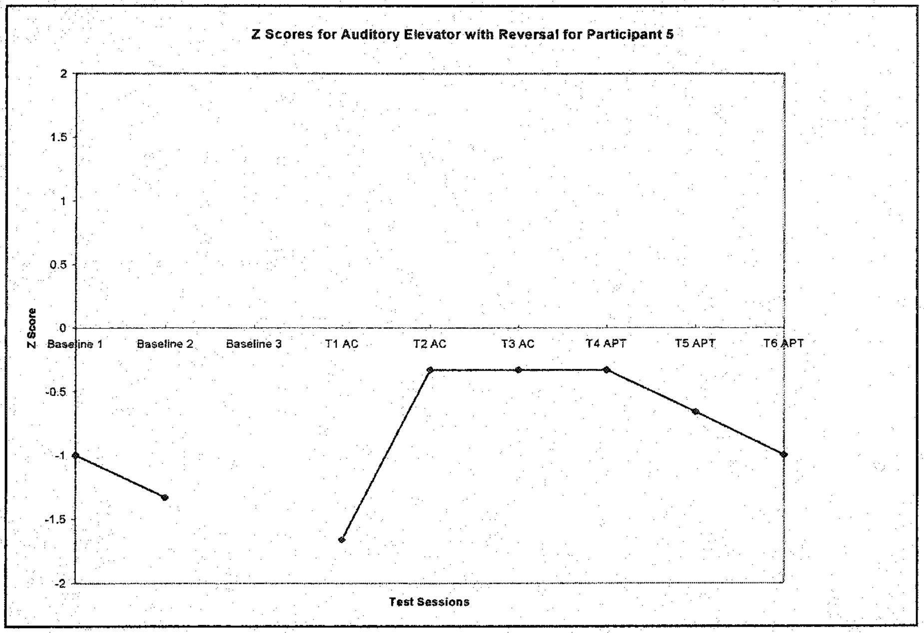

Figure 18. Z scores for the Auditory Elevator with Distraction task for Participant 5 for each test session.

Working Memory Task

Results for the computerized working memory tasks (Kerns, 1997; Owens, Morris, Sahakian, Polkey & Robbin, 1996) are discussed in this section. To reiterate this task briefly, participants were presented with a number of boxes (task one) and words (task two) on a computer screen. They were required to locate a number of symbols hidden beneath the words or boxes. This involved remembering where the boxes on the screen that had already been selected were located (spatial memory) and which words they had already chosen (verbal memory) (the words moved for every trial). Four trials for each task (box and word) were presented to each participant. They began with four items on the screen and this increased to six items, eight items and twelve items for the fourth trial. Reaction time and error rates were recorded. All participants were able to achieve ceiling performance for the four item trials.

Participant 1

As noted above, this participant achieved ceiling level performance for the four item condition for both the box and word task. She also achieved ceiling performance for the six item box task. For the box task, eight item condition, Participant 1 also tended to achieve ceiling, or near ceiling results, leaving little room for improvement. She demonstrated difficulty with the 12 item box task, making a number of errors and did not show a consistent improvement.

For the word task with six items she showed an improvement in error rate from baseline levels for during phase one of the study (APT). This was maintained throughout. However, she showed a large increase in errors for one test session which makes this data difficult to interpret. There was no corresponding improvement in reaction time. She showed a decrease in error rates for the eight item condition for the word task. This difference was observed during phase two (Active Control condition) (see Figure 19). Again, there was no corresponding improvement in reaction time. For the 12 item word task, Participant 1 also showed a drop in error rates observed during phase two (see Figure 20).

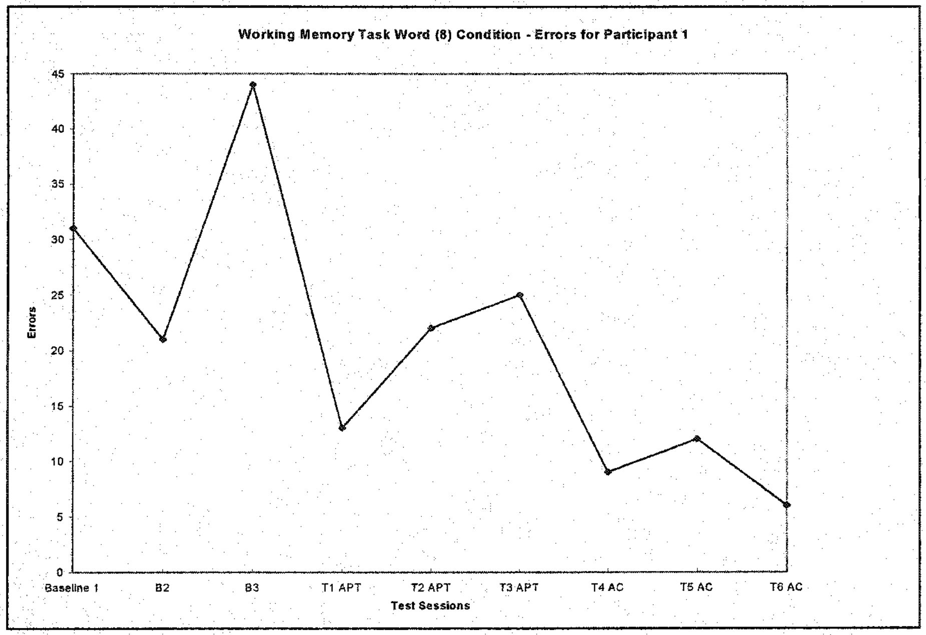

Figure 19. Errors for the Working Memory Word task (8 items) for Participant 1 for each test session.

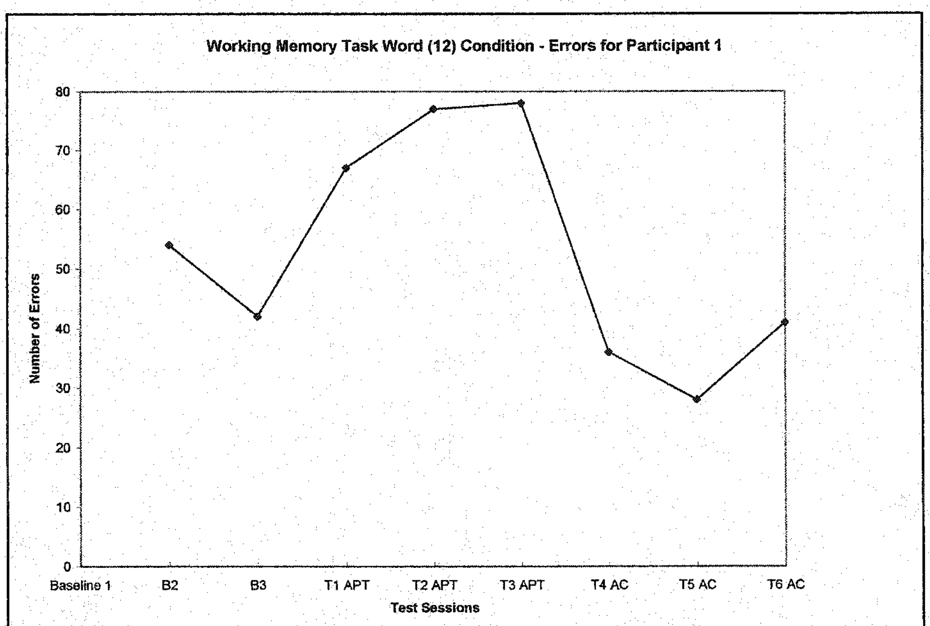

Figure 20. Errors for the Working Memory Word task (12 items) for Participant 1 for each test session.

Participant 2

Participant 2 achieved ceiling performance for the four item conditions for both the word and box tasks. He also achieved ceiling performance for the six and eight item box condition. For the 12 item box condition, this participant showed improvement in error rates occurring during phase one (APT). This improvement was not maintained and he showed an increase in error rates during phase two (Active Control) (see Figure 21).

Participant 2 showed an improvement in error rates to ceiling level for the six item word task during the APT condition. This was maintained during the Active Control condition (see Figure 22). There was no consistent improvement for the eight item word task, but he did show a decrease in error rates for the 12 item word task during APT. Performance deteriorated somewhat during the Active Control condition (see Figure 23). There were no corresponding changes in reaction time.

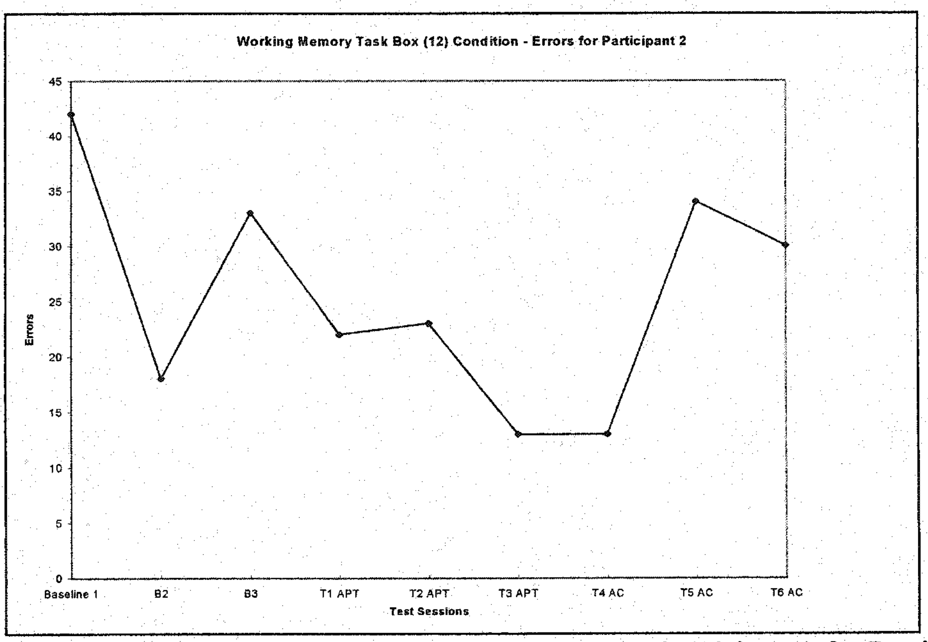

Figure 21. Errors for the Working Memory Box task (12 items) for Participant 2 for each test session.

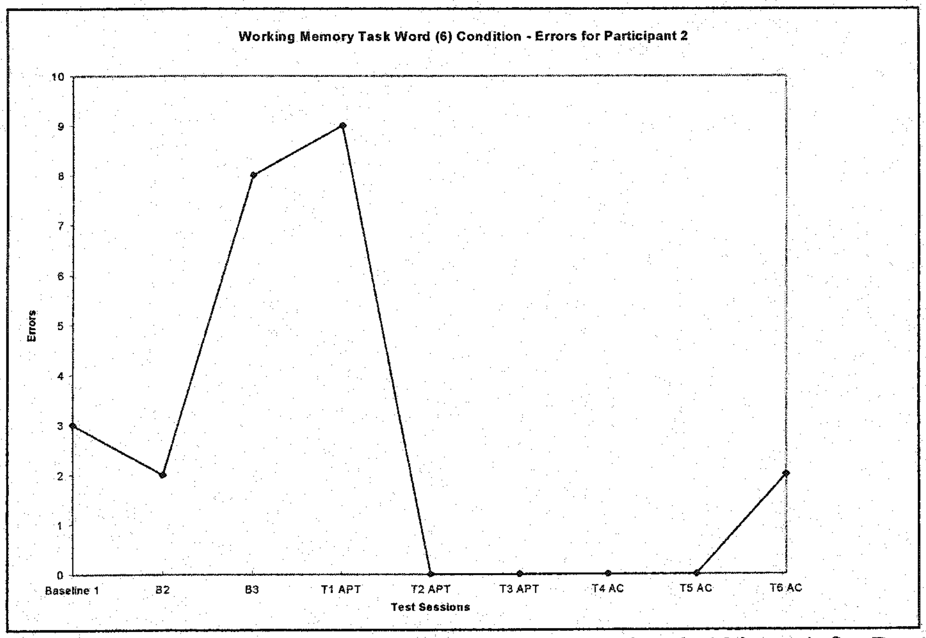

Figure 22. Errors for the Working Memory Word task (6 items) for Participant 2 for each test session

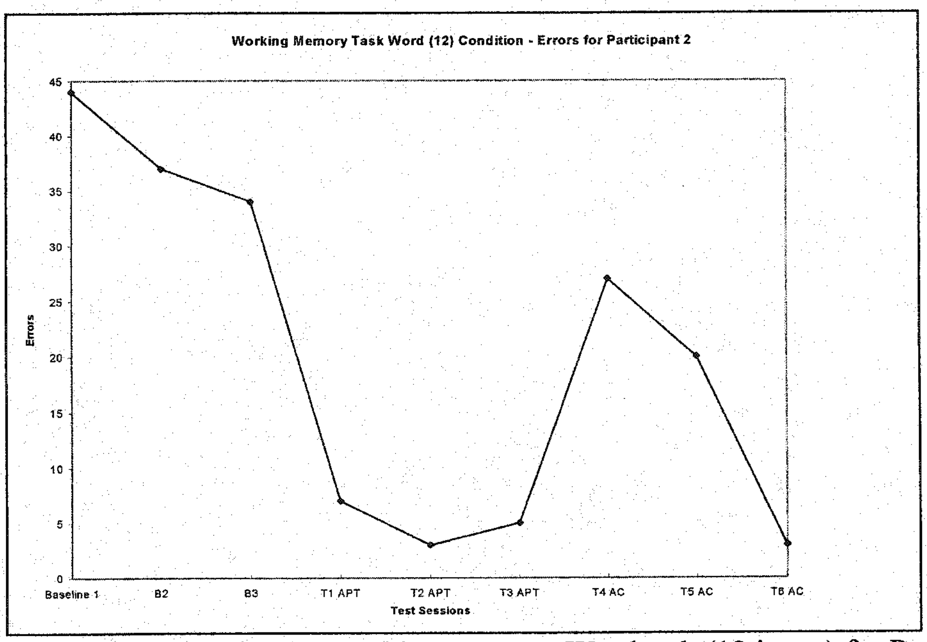

Figure 23. Errors for the Working Memory Word task (12 items) for Participant 2 for each test session

Participant 3

Similar to Participant 1, this participant achieved ceiling performance for the four item conditions for both the word and box tasks. He also achieved near ceiling performance for the six item box task. Performance for all other task conditions was variable and he did not demonstrate any consistent improvement in reaction time or error rate for any conditions.

Participant 4

Participant 4 showed at, or near, ceiling performance for the four and six item conditions for both the word and box tasks. For the eight item box task, this participant showed a decrease in error rates after the Active Control condition that was maintained to the end of the study (see Figure 24). There was no corresponding change in reaction time. For the 12 item condition, this participant also showed a reduction in error rates, notable during the APT phase (see Figure 25).

For the word task with eight items, Participant 4 showed a decreased error rate (see Figure 26) and increased reaction time (see Figure 27), suggesting possibly a trade-off between speed and accuracy. Data for the 12 item word task were not interpretable due to data for the baseline sessions being lost due to computer error.

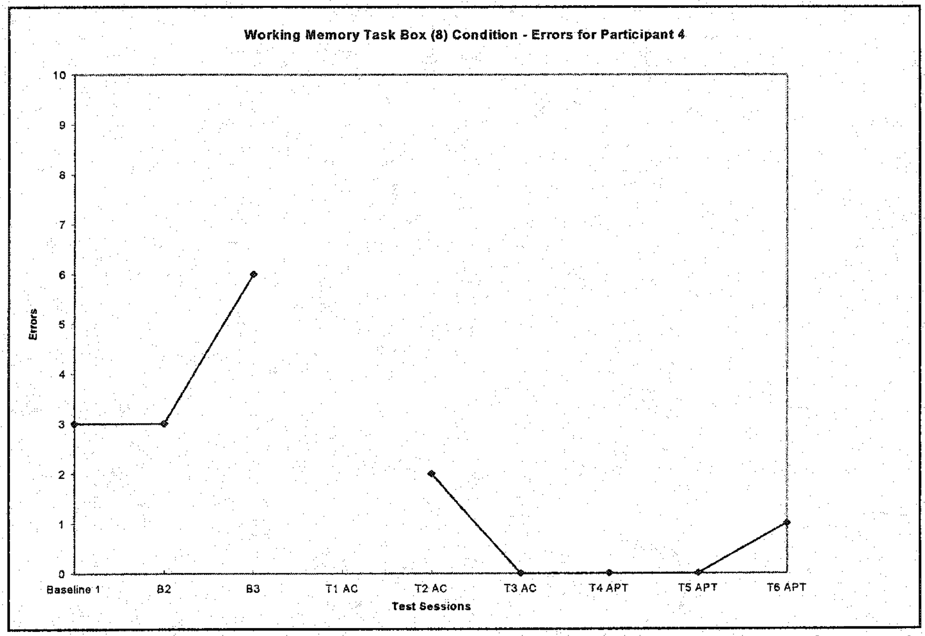

Figure 24. Errors for the Working Memory Box task (8 items) for Participant 4 for each test session

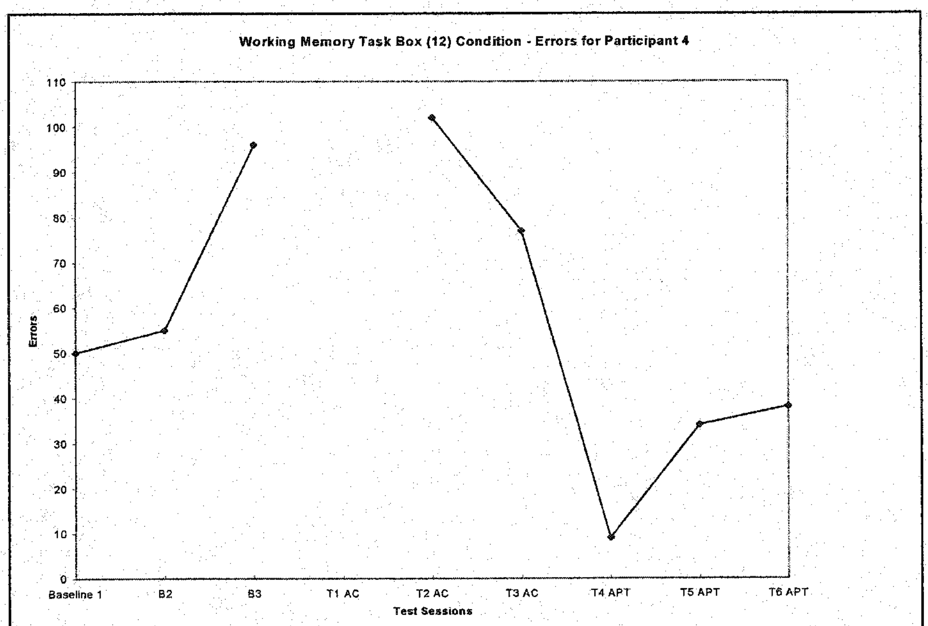

Figure 25. Errors for the Working Memory Box task (12 items) for Participant 4 for each test session.

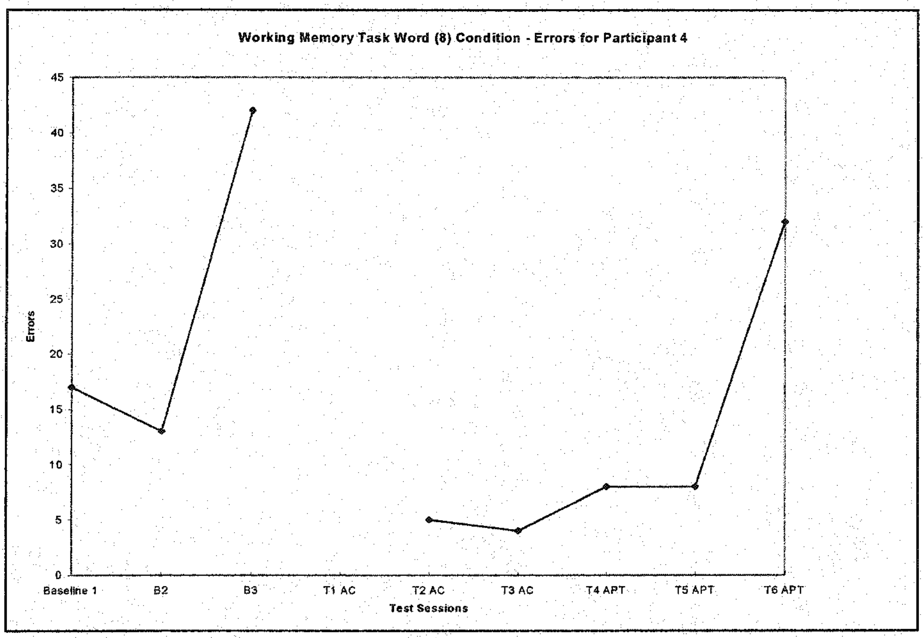

Figure 26. Errors for the Working Memory Word task (8 items) for Participant 4 for each test session.

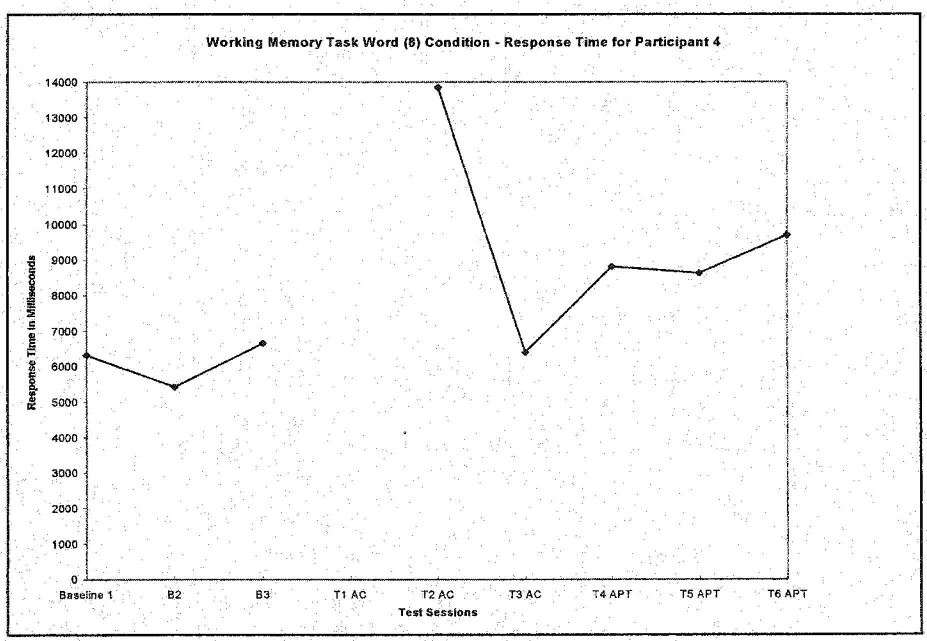

Figure 27. Response time for the Working Memory Word task (8 items) for Participant 4 for each test session

Participant 5

This participant achieved ceiling level performance for errors for the four and six item box and word tasks. There was a decrease in reaction time noted for the eight item box condition for the Active Control condition (see Figure 28). Error rates were variable. Performance was variable for the 12 item box condition, with no significant change from baseline.

For the word task, this participant showed a decrease in response time for the six item condition for both study conditions (as noted above, error rates were at ceiling) (see Figure 29). There was a similar decrease in response time observed for the eight item condition of the word task (see Figure 30). Errors were variable and demonstrated no consistent change from baseline. Finally, for the 12 item word task, this participant showed a drop in error rates for the last two test sessions only, during APT (see Figure 31).

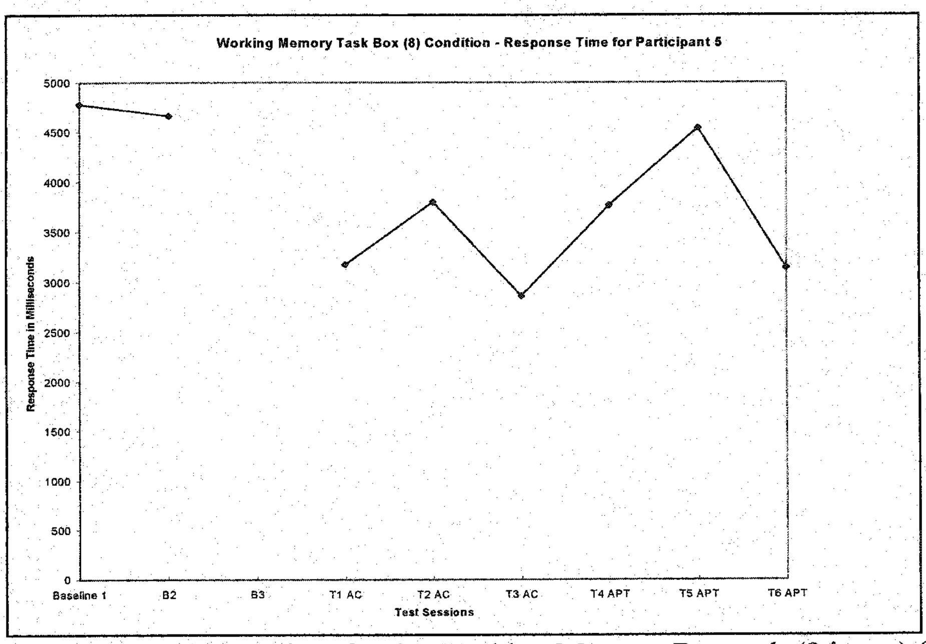

Figure 28. Response time for the Working Memory Box task (8 items) for Participant 5 for each test session.

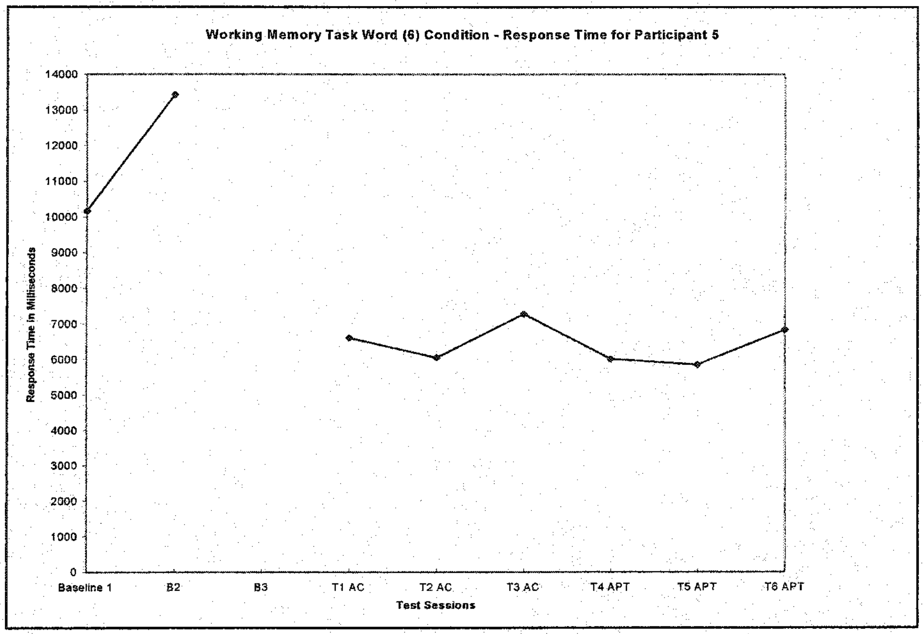

Figure 29. Response time for the Working Memory Word task (6 items) for Participant 5 for each test session.

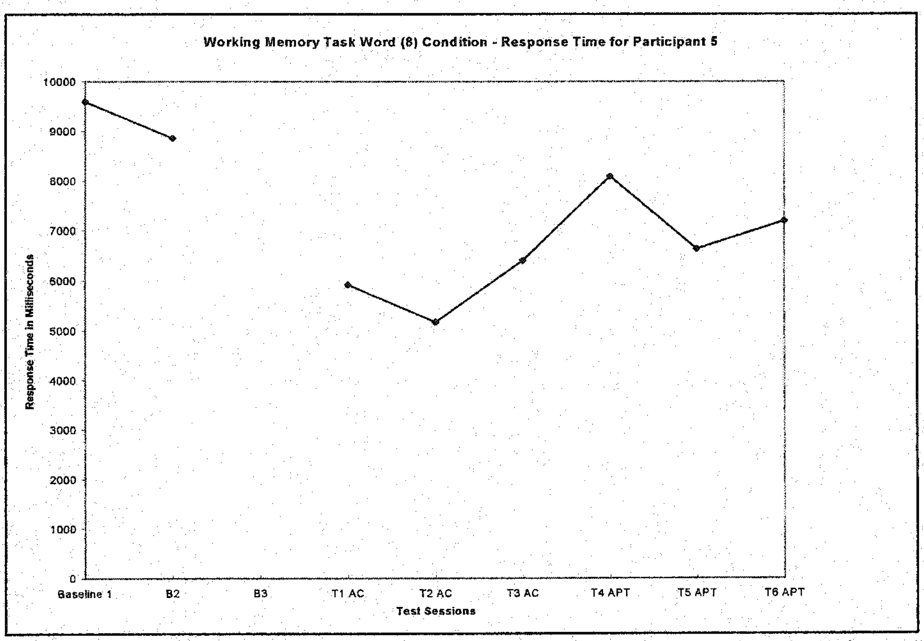

Figure 30. Response time for the Working Memory Word task (8 items) for Participant 5 for each test session.

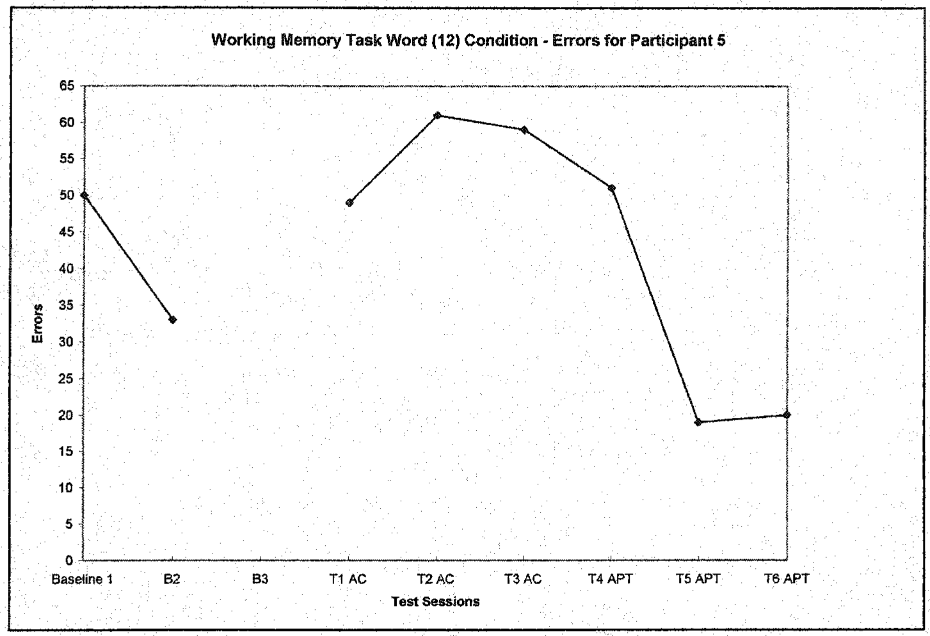

Figure 31. Errors for the Working Memory Word task (12 items) for Participant 5 for each test session.

Analysis of Self-report Data

Brief Self-Efficacy Questionnaire

Scores on the Brief self-efficacy questionnaire were examined as total scores and also as one score for attention-related self-efficacy questions and one for more general, domain non-specific items. Findings for all participants will be discussed together in this section.

Three of five participants did not demonstrate any change in self-efficacy scores. Participant 1 did not appear to have increased self-reported feelings of self-efficacy when total score was graphed. However, graphing of attention specific items revealed an increase in scores throughout the entire test period (APT and Active Control modules) (Figure 32). Results for Participant 2 were more variable, however he showed an increase in self-efficacy score for all three indices. Overall scores on the brief self-efficacy questionnaire are shown in Figure 33. Mean scores for each participant for each condition are presented in Table 4.

Table 4.

Scores on the Self-Efficacy Questionnaire for all Participants
Note. Overall scores are out of 50, APT and General scores are out of 25.

Participant 1	Baseline	Active Control	APT
Overall SEQ	33.6	37.3	38.3
Attention SEQ	14.6	17.6	18
General SEQ	19	19.6	20.3

Participant 2	Baseline	Active Control	APT
Overall SEQ	30.6	35.6	34.5
Attention SEQ	15	17	17
General SEQ	15.6	18.6	17.5

Participant 3	Baseline	Active Control	APT
Overall SEQ	27.8	n/a	31
Attention SEQ	13.1	n/a	14.6
General SEQ	14.6	n/a	16.3

Participant 4	Baseline	Active Control	APT
Overall SEQ	33.6	35.5	34.6
Attention SEQ	17.3	16.5	17.6

General SEQ	16.3	19	17

Participant 5	Baseline	Active Control	APT
Overall SEQ	32	30.3	30.3
Attention SEQ	14	14.6	14
General SEQ	18	15.6	16.3

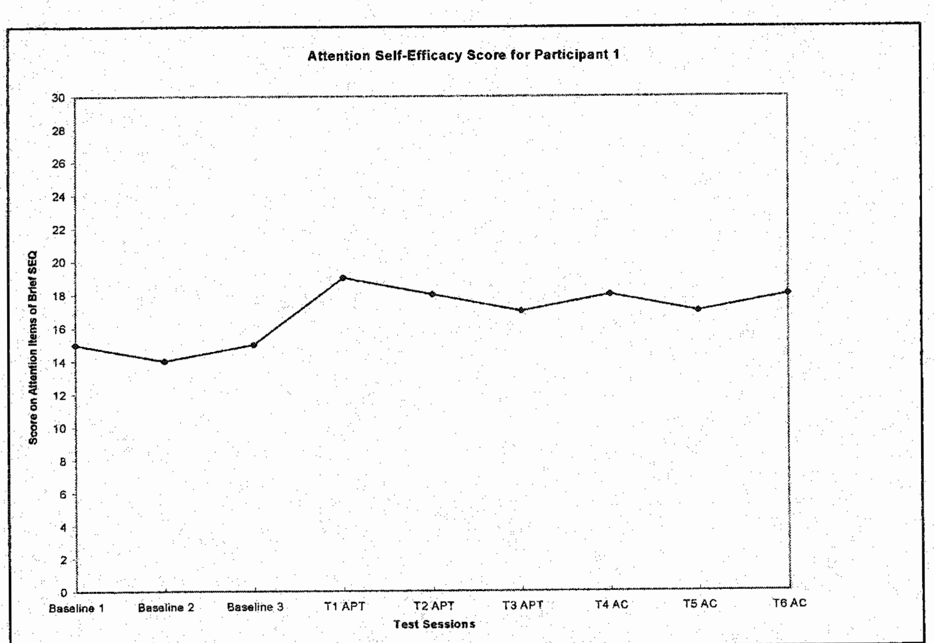

Figure 32. Scores on Self-Efficacy Questionnaire (attention related items only) for Participant 1 for each test session.

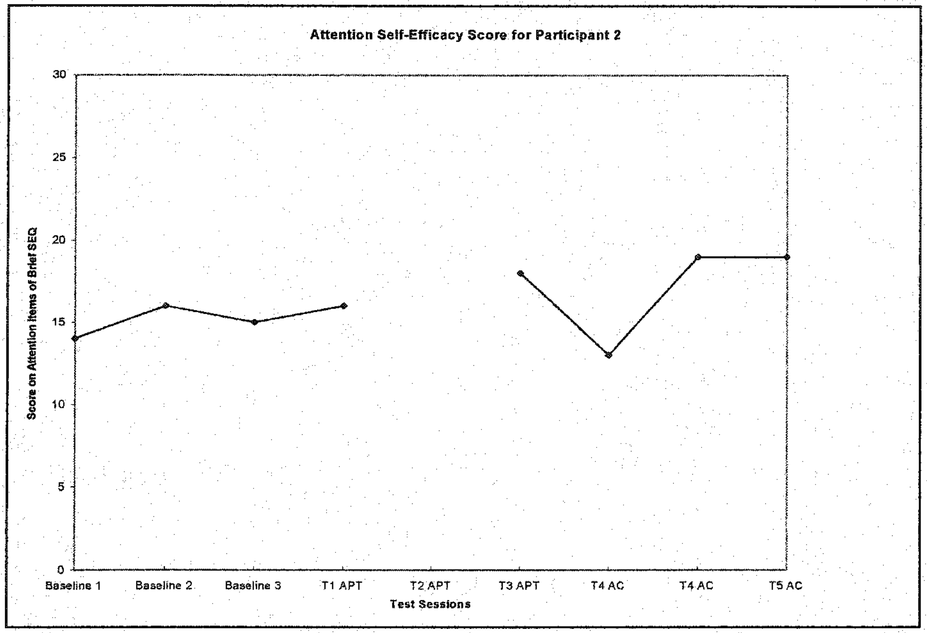

Figure 33. Scores on Self-Efficacy Questionnaire (attention related items only) for Participant 2 for each test session.

Attention Self-Ratings

Participants' daily self-ratings of attention behavior is discussed in this section. There are a different number of observations for each Participant 3ue to variability in consistency of charting by each person.

Participant 1

This participant reported essentially no attention problems throughout the entire duration of the study, with the exception of two days during the Active Control condition when she endorsed nearly all items indicating significant difficulties with attention. Her husband rated her attention during the baseline period only. His data were not consistent with hers and indicated difficulties with attention.

Participant 2

Participant 2 did not demonstrate a stable baseline for recording of attention behavior. Therefore, it is difficult to determine if there was any real change in terms of ratings of attention behavior related to the interventions employed.

Participant 3

There were no significant changes in attention ratings observed for this participant.

Participant 4

Participant 4 demonstrated a reduced number of reported attention problems for the Active Control condition. However, there is considerable variability in his reporting. There are only three data points available once APT had begun (See Figure 34).

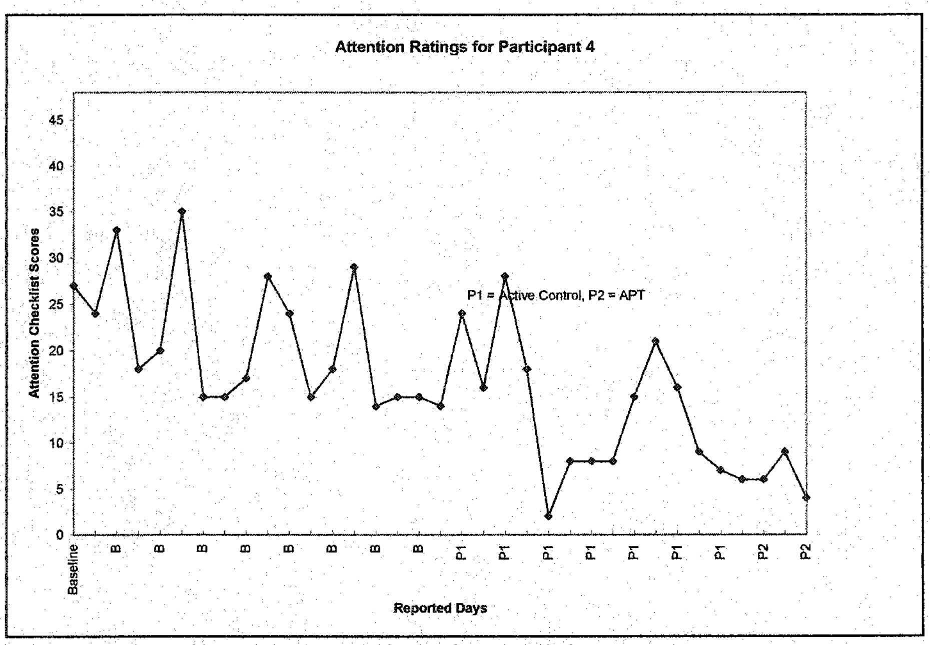

Figure 34. Daily attention ratings for Participant 4.

Participant 5

This participant showed an interesting pattern. Reporting of attention problems was lower for the baseline phase than for the Active Control condition. During APT reporting of attention problems returned to baseline levels and on some days, was lower than during the baseline phase (see Figure 35). This participant reported improved mood during APT and stated that he enjoyed "exercising" his brain.

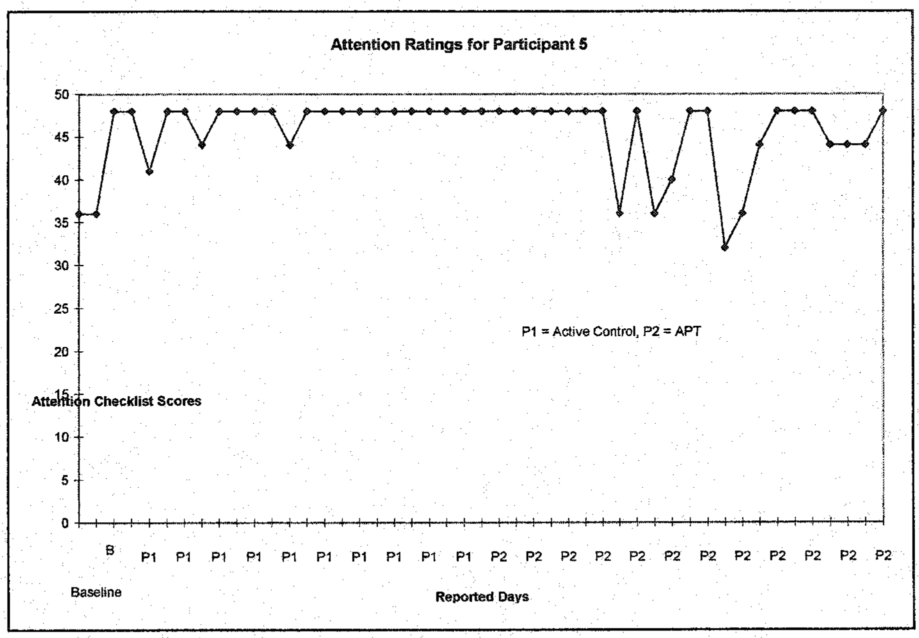

Figure 35. Daily attention ratings for Participant 5.

DISCUSSION

Considerable support for the various hypotheses advanced was found. Findings for neuropsychological, neurophysiological and self-report variables will be discussed separately. This will be followed by a discussion of the primary question posed by this study: is there a specific effect for the administration of pure attention training (APT) above and beyond a supportive, adjustment-oriented approach.

Neuropsychological Test Results

Data provided some support for the hypothesis that performance on neuropsychological tests would show the most change after participation in the APT only condition. Two participants (Participants 2 and 5) demonstrated improvements on selected tasks of the TEA following and/or during APT training. For Participant 2, APT was delivered prior to participation in the Active Control condition. For Participant 5, APT was delivered following Active Control. In general, changes were associated with participation in APT only, regardless of order of administration of therapeutic conditions. There was one exception; Participant 5 demonstrated an improvement for the Auditory Elevator with Distraction task during the Active Control condition which continued during APT.

Despite these positive findings, consistent improvement on TEA tasks could not be detected for the three other participants. Part of this may have been due to the fact that ceiling effects were seen on most of the TEA tasks, reducing their potential to demonstrate or detect change. However, participants 3 and 4 did not reach ceiling levels on all tasks, but still did not demonstrate improvement

The computerized working memory task employed in the study proved to be a more sensitive index of improvement. Four out of five participants showed improved performance on these tasks. For three participants, improvements were evidenced after/during participation in APT, regardless of order of administration. Participant 5 did show reduced response time beginning during the Active Control condition. However, his error rates did not drop until APT was instituted. Therefore, the improved response time may be related to practice effects. Participant 1 demonstrated improvement during participation in the Active Control condition. However, she received APT prior to the Active Control condition, therefore carry-over effects cannot be ruled out. Participant 3 did not demonstrate any changes, consistent with his performance on the TEA.

Our findings provide support for a non-significant trend observed in the data of Solhberg and colleagues (in press). They employed a similar working memory task in a similarly designed study comparing APT to placebo treatment (psychotherapeutic support and brain injury education) using both within and between subjects methodology. Improvements on their working memory task were noted with greater improvement after participation in APT. However, the difference between APT and placebo did not reach significance.

The strength of the repeated measurement, single case design methodology employed by the current study allowed for the elucidation of better performance after APT that may have been obscured in group analyses. Repeated testing (3 times per condition) provided stronger evidence that performance was linked to therapeutic condition than would have been obtained with a simple post-test design. Similarly, repeated baseline testing adds to the control of practice effects which stabilize during baseline sessions. It is plausible that some degree of practice effects did occur on TEA tasks, as evidenced by some participants reaching ceiling levels during baseline. Alternate forms were used, but they employed the same tasks; participants may have benefited from familiarity with the task demands which did not change over forms. The implementation of an active control condition provided control over placebo effects. There were no differences in the working memory task and only one difference in the TEA tasks observed after Active Control (unless it was preceded by APT).

It is unlikely that Participant 5 improved on the Auditory Elevator with Distraction task during Active Control due to practice effects because he demonstrated a consistent baseline performance which continued for the first test session during the Active Control condition. Perhaps increased motivation as a result of being involved in the study played a role. However, one would expect to see motivation effects occurring for all tasks if they were truly present. The three subtests of the TEA tap different attentional processes. It may be that this participant was more impaired on tasks of visual selective attention, speed of processing, and sustained attention than for auditory selective attention and resistance to distraction. Compensations learned in the Active Control condition may have enabled this participant to achieve better performance on this task but not on the other tasks.

In summary, all but one participant showed some improvement on neuropsychological measures following participation in APT. This provides strong support for the idea that it is the targeted cognitive practice that improves performance and not psychotherapeutic support. These results are particularly positive in light of the fact that the neuropsychological tests employed were quite different from the training tasks. This is particularly true of the working memory tasks which were presented on computer. None of the training tasks involved working with a computer.

Neurophysiological (ERP) Results

Data provided support for the hypothesis that neurophysiological variables (P300 and N200) would show the most change after participation in the APT condition. All five participants demonstrated some change in ERP variables for both visual and auditory tasks after participation in APT. For the two participants who received APT prior to participation in the Active Control condition (Participants 1 & 2), ERP changes were maintained, or in the case of Participant 1, actually became more pronounced. This coincides with her improved performance on the working memory tasks during Active Control. For the rest of the participants, there were minimal changes in ERP variables noted during participation in the Active Control condition.

The ERP changes observed were generally in the expected direction. Decreased P300 latency was predicted and was observed for two of five participants for the visual task. Directionality of amplitude changes for the P300 were not predicted because of the sensitivity of P300 amplitude to variables such as arousal level, amount of attention paid to stimulus, and confidence and/or certainty (Picton, 1992; Polich, 1998). There are also conflicting reports regarding whether P300 amplitude is reduced (Heinze et al., 1992; Papincolaou et al., 1984) or increased (Gibrich, Nau, & Zerbin, 1986) in the TBI population. Four participants showed increased P300 amplitude and two participants showed decreased P300 amplitude (for the visual task). There were only four N200 changes observed in the expected direction. Decreased N200 latency was observed for one participant. Three participants demonstrated decreased negativity of the N200. Participant 2 demonstrated increased N200 latency; this was not predicted by the hypotheses advanced.

P300 latency is considered to be a measure of stimulus classification speed (Kutas et al., 1977) or information processing efficiency (Segalowtiz & Barnes, 1993). Therefore, a reduction in latency of this component suggests improved information processing speed for two participants in the study. Polich (1999) describes P300 latency as a sensitive temporal measure of neural activity underlying the processes of attention allocation and immediate memory. It has been associated with superior cognitive performance in normal subjects (Emmerson et al., 1990).

P300 amplitude changes are more difficult to interpret because of the complex interactions of the influence of extraneous variables, as discussed above. Four participants in the current study demonstrated increased P300 amplitude values. Because a reduction in P300 amplitude has been interpreted by many as an indication of reduced cognitive capacity, the increase may reflect improved attentional capacity. It may also reflect greater attention given to the task stimuli, perhaps as a result of improved attention.

The decrease in amplitude observed in two participants can also be explained by examining the factors that affect the amplitude of the P300. Theoretically, a decrease in amplitude could also reflect improved attentional abilities. When adequate attention is paid to a task, amplitude and certainty are believed to covary (Picton, 1992). Therefore more certainty of the correct response could be associated with decreased amplitude. In a similar vein, amplitude varies with task difficulty. A less difficult task would produce a smaller amplitude P300. If participants' attentional abilities have improved, the task may have become easier resulting in a smaller amplitude P300. Conversely, amplitude also varies with arousal level and amount of attention paid to a task. Therefore, poor attention and/or effort could also result in decreased amplitude. Examination of behavioral data for the visual ERP task revealed that participants made few errors during all five administrations of this task. This weakens the notion that reduced amplitude is evidence of reduced task difficulty or greater certainty. Participant 1 demonstrated increased amplitude for the auditory task and decreased amplitude for the visual task. This finding suggests that amplitude changes, at least for this participant, were either related to modality specific differences in response to attention training or to state factors, such as arousal level. The difference in directionality of amplitude changes observed across subjects and within subjects (Participant 1) weakens the evidence that bi-directional changes in amplitude reflect valid ERP changes related to the rehabilitation exercises. Theory predicts that increased amplitude may reflect changes associated with improved attention but decreased amplitude is more likely related to changes in state (arousal level) across test sessions. Therefore, it is felt that the latency changes are a more valid indicator of improvement in attentional processing.

N200 latency, like P300 latency, is thought to be related to the timing of feature extraction processes (i.e., recognition of high tone or low tone) (Gevins & Cutillo, 1971). One participant demonstrated reduced N200 latency for the auditory task. This participant (5) also demonstrated reduced latency of the P300 for the auditory task. This suggests improved information processing speed. Participant 2 demonstrated increased

N2 latency which was not expected. However, he also demonstrated decreased negativity of the N2 which will be discussed below.

N2 amplitude is believed to index the effort associated with stimulus categorization; it has been argued that individuals with TBI must apply more effort to evaluate the significance of incoming information (Clark, O'Hanlon, Wright & Geffen, 1992). Three participants demonstrated decreased negativity of the N200. This implies reduced effort required to carry out the task. No participants demonstrated increased negativity of the N2.

ERP measures proved to be more sensitive than the more traditional neuropsychological measures (TEA) employed in this study in detecting change after attention retraining. All participants showed some change in one of the ERP components examined. Participants who demonstrated the highest number of changes on neuropsychological measures also demonstrated more ERP changes. This suggests some relationship between the ERP measures and functional recovery as indicated by improved performance on neuropsychological tests. Whether or not these ERP changes reflect underlying neuronal change remains speculative. Neural generators of the P300 have yet to be elucidated, although candidates are the hippocampal region of the medial temporal lobe (Molnar, 1994), the temporoparietal junction, (Knight et al., 1989) and more frontal cortical regions (Ford et al., 1994). Plastic neuronal changes such as increased dendritic branching as a result of repeated stimulation may underlie the observed ERP changes.

There are a number of extraneous factors that may account for changes in ERPs over repeated measurement. It is well known that external task parameters influence the amplitude and latency of the P300. These include stimulus intensity, task difficulty and probability of presentation of target stimuli. Because the same tasks were used repeatedly, these factors were well controlled. Biological variables also exert an influence on ERPs (Polich, 1998; Lin & Polich, 1999; Ravden & Polich, 1999). Because this study used participants as their own controls, constitutional variables such as gender, handedness, and intelligence were constant across measurements. Ultradian rhythms (90 minute biological cycles) have been shown to influence ERP measures (Ravden & Polich, 1999). By testing participants at approximately the same time each session, an attempt was made to exert some control over these variables. State variables such as arousal level could not be controlled beyond encouraging participants to make their best effort each test session. Related to arousal level is the habituation of P300 amplitude. This has been documented for the oddball task (Polich, 1998) in which the continual, repetitive nature of the task can result in habituation. Although this may have been a factor in this study, habituation would likely have occurred during all five test sessions and therefore should not have played a role in accounting for differences observed between test sessions. P300 latency does not appear to demonstrate habituation effects (Ravden & Polich, 1999).

Variability of the amplitude and latency of the P300 component across test sessions has been systematically studied by a number of authors (Polich, 1986; Segalowitz & Barnes, 1993; Sklare & Lynn, 1984; Delabout & Robey, 1997). Estimates of reliability for young adults across test session intervals of two to four weeks for P300 latency was felt to be adequate to support its use as a reliable measure for both clinical and research applications (Sklare & Lynn, 1984). Segalowtiz and Barnes (1993) reported that latency is a much more stable measure than amplitude and only varies by 20 msec with extreme drowsiness. Delabout and Robey (1997) also found amplitude to be more variable than latency. They reviewed relevant studies and concluded that P300 latency and amplitude had reliabilities well within the range required for group studies. The findings of these studies and control of extraneous variables lend support to the assertion that the ERP changes observed in this study reflect true change due to attention retraining.

The findings of the current study add to a very small body of research that suggests that ERP changes occur after cognitive rehabilitation (Baribeau, Ethier & Braun, 1989; Stone & Raskin, 1996). Sohlberg and colleagues (in press) did not find ERP changes after attention re-training but they utilized a group design with a small number of participants and group analysis may have obscured delineation of individual positive results.

Self-Report Results

Data provided limited support for the hypothesis that participation in the rehabilitation program (APT and/or Active Control) would produce changes on a measure of self-efficacy. Two participants (1 & 2) showed increased reporting of feelings of self-efficacy during APT which continued during the Active Control condition. For one participant, the improvements were noted for attention specific items only on the self-efficacy questionnaire. This provides support for the idea that a rehabilitation context provides the requisite characteristics for increases in feelings of self-efficacy to occur: verbal persuasion, reduction of physiological arousal, personal performance accomplishments, and vicarious experience (Bandura, 1977). Because the two participants showed increased feelings of self-efficacy during the APT phase, it is possible that personal performance accomplishments on APT tasks and reduction of physiological arousal while doing the tasks was the predominant mechanism through which increased feelings of self-efficacy were achieved. Interestingly, all participants generated self-efficacy scores at about the same level at pre-test. To my knowledge, this is the first time that self-efficacy has been systematically examined in a TBI population. These results provide preliminary evidence that self-efficacy beliefs for both general and attention specific tasks can be modified through participation in a rehabilitation program. However, it is not possible to ascertain the specific impact of each therapeutic condition on self-efficacy beliefs.

Similar to self-efficacy questionnaire results, data also provided limited support for reduction of daily attention problems during the interventions, as indicated by decreased reporting of attention problems on the attention rating scale. Two participants (4 & 5) showed decreased reporting of attention problems in daily life. Interestingly, these participants each demonstrated a different pattern of improvement relating to treatment condition. Both participated in the Active Control condition first, followed by group administered APT. Participant 4 showed reduced reporting of attention problems during the Active Control condition. This trend appeared to continue during APT but a small number of data points limits firm conclusions about the impact of APT for daily reporting of attention problems for this participant. Conversely, Participant 5 demonstrated reduced reporting of daily attention problems during the APT condition. This participant actually showed increased reporting of daily attention problems during the Active Control condition. As noted briefly in the results section, these two participants could be characterized as the "most positive" (Participant 4) and "least positive" (Participant 5) participants in the study in terms of their attitudes toward their injuries. They received the same intervention protocol, therefore it can be concluded that the differences in observed attentional improvements relates in some way to the interaction of their individual characteristics with the treatment condition.

Participant 4 exhibited few symptoms of depression and a very positive coping style. He viewed himself as lucky to have survived his accident and enjoyed his life, despite significant physical and cognitive limitations. He had a happy disposition and used humour frequently. It can be conjectured that this positive affective state allowed him to be fully present emotionally in the Active Control sessions. He listened and asked many questions and reported trying some of the compensations and relaxation strategies learned in the group at home. His implementation of compensatory strategies may have been responsible for his observation of reduced attention problems during the Active Control condition.

Participant 5 was in considerable emotional distress. His score on the Rand Depression Scale indicated significant symptoms of depression. He was observed to become emotionally volatile and sometimes angry during the Active Control condition when discussing his life circumstances. Without continual redirection from the group facilitator, he quickly dominated the conversation and tended to use the group as a "venting" session. It is possible that the Active Control sessions allowed this participant to ruminate on his difficulties. Clinical observation revealed that with redirection, he was able to participate in discussions about cognitive restructuring and was open to feedback from other group members regarding his verbal aggressiveness and ruminative monologues. However, this did not translate into improved self-ratings of attentional problems.

During APT Participant 5 reported decreased attentional problems. He stated that he enjoyed this phase of the rehabilitation program and that he felt like he was finally "exercising his brain." There are two possible explanations for Participant 5's reduced reporting of attentional problems during APT. Improved attention, secondary to APT, may have genuinely resulted in reduced attentional problems during daily life. This is, in fact, a strong possibility, as this participant demonstrated a number of evoked potential and psychometric improvements during APT coinciding with reduced reporting of attentional problems. An alternative explanation is that this participant felt empowered and more positive during APT and a placebo effect created the illusion that he was having less difficulty with attention on a daily basis. However, if this was the case, one would expect to see increased feelings of self-efficacy during APT and this did not occur. Regardless of the reasons underlying the observed findings, they point to the potential impact of different patient characteristics on treatment response.

Decreased reporting of attention problems was not found for Participants 1, 2 or 3. Participant 1 endorsed very few difficulties with attention. Her husband filled out the attention scale, the post-concussive checklist, and the verbal aggressiveness scale. On all three of these measures his report consistently indicated more problems than Participant 1's report. This is consistent with other authors' observations that patient and significant other report are often inconsistent (Bennet-Levy & Powell, 1980, cited in Ponsford & Kinsella, 1991; Oddy, Coughlan, Tyerman, & Jenkins, 1985). This suggests that Participant 1's level of awareness of her difficulties was limited. Extremely variable reporting of attention problems during baseline made it difficult to draw conclusions for

Participant 2. Participant 3 did not demonstrate any consistent change on attention ratings.

All participants showed reduced reporting of post-concussive symptoms after participation in the rehabilitation program. Data was not available to delineate differential effects of the two treatments. There was no significant change for all participants on Verbal Aggressive Scale indicating that changes observed on self-report measures were not due to halo effects. Mood, as measured by the MS, was relatively stable throughout the study.

Comprehensive Discussion of All Results

In addressing the primary question posed by this study: is there a specific effect for the administration of pure attention training (APT) above and beyond a supportive, adjustment-oriented approach, the data point to APT as being the efficacious ingredient in terms of producing cognitive and neurophysiological change. With the exception of one participant's improvement on one neuropsychological task following the Active Control condition, and another showing improvement on one task during Active Control followed by APT, all participants demonstrated change following participation in APT only. For those two participants who received individually administered APT prior to the Active Control condition, changes were maintained during Active Control. For those who received Active Control first, changes were not noted until attention retraining was initiated. For the self-report variables (self-report of attention problems and self-efficacy ratings), the interaction between treatment modality and improvement was more complex and appears to be mediated by individual patient characteristics.

The current findings add to the list of studies that have shown cognitive rehabilitation, and more specifically attention retraining, to be efficacious with individuals with TBI (Sohlberg & Mateer, 1987; Neimann, Ruff & Baser, 1990; Sturm, Willmes, Orgass & Hartje, 1997; Gray, Robertson, Pentland & Anderson, 1992; Gray & Robertson, 1989; Wilson & Robertson, 1992; Ruff et al., 1994; Nag & Rao, 1999; Franzen & Harris, 1989). The current findings also contribute to a very small body of literature that has examined the differential impact of targeted cognitive practice and more general, therapeutic or psychoeducational approaches (Sohlberg et al., in press; Ruff et al., 1989; Schmitter-Edgecombe et al., 1995; Ruff & Neimann, 1990).

The most similar study in terms of research question, training materials, and study design is that of Sohlberg and colleagues (in press). They were interested in how APT would compare with a placebo condition (supportive therapy, psychoeducation, relaxation training) in improving attention and memory functioning. The current study supports their finding of order effects, that placebo was effective when delivered after APT. In the current study, improvements observed during APT were continued during the Active Control condition. In the case of Participant 1's performance on the working memory task, improvements were noted during Active Control, delivered post-APT. Sohlberg and colleagues suggested that APT mobilized cognitive resources resulting in follow-up effects.

In terms of differential effectiveness of the two conditions, our findings were generally more definitive. In the Sohlberg study, improvements were noted for both conditions with a non-significant trend toward APT being more effective. The single case design of the current study yielded more sensitivity in detecting differences between conditions. Although the Sohlberg group used both a within and between subjects design, their data was analyzed by group. Confidence in the current findings is bolstered by the fact that the effect of APT was demonstrated over five participants. Ruff and colleagues (1989) found similar non-significant trends suggesting superiority of computerized cognitive retraining over more psychotherapeutic/educational sessions, however improvements were observed for both conditions.

As noted above, self-report data revealed that participants with different characteristics responded to APT and the psychoeducational and psychotherapeutic condition differently, in terms of their own observations of improvement. This highlights the importance of examining patient treatment interactions. A benefit of single case designs is that they allow for detailed examination of participant characteristics and their relationship to outcome. A number of authors have alluded to the importance of delineating these factors (Wilson, 1993; Ben-Yishay & Diller, 1993; Cicerone et al., 1996).

Several patient characteristics that may impact rehabilitation outcome have been suggested; these include, but are not limited to, chronicity of injury, age, severity of initial injury, location of injury, level of emotional reactivity, and social supports. Middleton and colleagues (1991) attempted to look at the variables of age, time post-injury and severity of injury in their study of the efficacy of computer-assisted cognitive rehabilitation. No significant effects were found. MacNiven and Finlayson (1993) have suggested that examination of these factors in interaction and not in isolation may be a more valuable way to understand the role of these variables in predicting recovery.

Examination of the current findings reveals that those participants with the least severe initial injury showed change on the greatest number of measures (Participants 2 and 5). Neither of these participants was in coma, however both demonstrated significant periods of post-traumatic amnesia (PTA). Another notable similarity of these two participants was the presence of depressive symptomatology. Clinical lore exists that suggests that depression may be a contra-indicator for treatment because a depressed individual may not have the emotional resources to benefit from a treatment program. Our results suggest otherwise. Involvement of individuals with depressive symptomatology may provide an opportunity for behavioral activation and distraction from or re-focusing of negative beliefs. However, it should be noted that depression was measured in this study using only the Rand depression inventory and was not assessed using specific diagnostic criteria (i.e., the DSM-IV). Therefore, these findings may not hold for individuals who meet the DSM-IV criteria for Major Depressive Episode.

It has been suggested that treatment success is inversely related to time since injury (Franzen & Harris, 1993). However, this finding may be somewhat spurious because numerous studies utilize patients who are still in a period of significant spontaneous, or natural, recovery. In the current study, participants ranged from 15 months to 12 years post-injury, spanning a very wide range of chronicity. Changes were shown by all participants, regardless of time since injury. This suggests that the inverse relationship between time since injury and treatment success does not hold for individuals who have reached a plateau in terms of natural recovery. Participants also varied considerably in terms of age (22 to 58 years). Age did not seem to be a factor in treatment success; Participant 3 showed the least improvement and he is aged 22 years, while Participant 5, aged 40 years, showed improvement on a number of measures.

Participant 3 deserves individual mention because he showed the least amount of improvement. Two main factors differentiate this participant from the others. Firstly, he did not participate in the Active Control condition. Due to employment commitments, he was unable to attend those sessions and instead underwent an extended (six test sessions) baseline, followed by participation in the group administered APT. Secondly, he had a pre-existing Attention Deficit Disorder. In terms of severity and time since injury he is comparable to other study participants. His injury is classified as severe and he was 29 months post-injury.

Several possible explanations for his results follow from examination of his characteristics. It is possible that participation in the Active Control condition was a necessary prerequisite for successful participation in APT. By not participating in that condition, Participant 3 may not have attained the requisite knowledge about brain injury or the cognitive strategies to manage distress that the other participants possessed. This explanation is weakened by the fact that Participants 1 and 2 received APT prior to the Active Control condition and yet demonstrated improvement on dependent measures during/after APT.

It is more likely that Participant 3's lack of improvement is related to pre-existing attention problems. Although he subjectively felt that he had "outgrown" the Attention Deficit Disorder prior to the accident, he did note that it seemed as if the accident "brought the attention problems back 100%." At the level of the cognitive construct of attention, it may be that this participant's attentional abilities were more limited premorbidly and therefore were less responsive to treatment. At a neuroanatomical level, if one accepts the assertion that neuronal alteration underlies improved attentional abilities, it may be that this young man's brain is limited in neural redundancy. To illustrate this point, consider the observation that individuals who sustain traumatic brain injuries are more susceptible to the degenerative processes associated with aging (Luukinen, Viramo, Koski, Laippala, & Kivela, 1999). It has been theorized that neural modifications used to support recovery from insult early in life are either more susceptible to aging, or are the same modifications that are used during aging. Therefore, age related adaptations cannot be made and age related cognitive decline is evidenced (Kolb, 1999). It is feasible that individuals who have pre-existing neurological or developmental problems do not possess the ability to make neural modifications in much the same way as the aging brain that has already "used up" its neural reserve recovering from an earlier injury, does not. Therefore, these individuals may be less amenable to treatment. Wilson (1998) discusses the concept of "cognitive reserve" and she quotes Symonds who said "it is not only the kind of head injury that matters but the kind of head." This is not to say that individuals with ADHD cannot benefit from attention retraining. In fact, promising results have been reported using attention retraining materials with children with ADHD (Kerns, Eso, & Thomsen, 1999). However, the combination of ADHD and TBI may render the cognitive deficits more resistant to intervention.

All studies of the efficacy of cognitive rehabilitation techniques must address the issue of generalization. That is, do the improvements observed on training tasks or outcome measures generalize to improvements in the patients' lives? Generalization can be demonstrated on a number of levels: improvements on tasks similar to training tasks, on tasks different than training tasks, and in daily activities. Typically, generalization is assessed using observations, self and other report, and interview.

In the present study, improvements were demonstrated on non-training tasks. The outcome measures employed provide stronger evidence of generalization than studies that have used standard neuropsychological tests such as the PASAT; it is quite similar to training tasks and bears little similarity to functional activities. Test of Everyday Attention (TEA) tasks were different from training tasks and incorporated some elements of "real-life" demands. The computerized working memory tasks that were employed were an additional step removed from training tasks in that they were delivered on computer and introduced a memory component. This is very different from the training tasks that were utilized.

Generalization above and beyond laboratory tests was assessed using daily attention ratings. As discussed earlier, only two participants demonstrated consistent change on the attention rating scale. The usefulness of this measure was limited by variable reporting and level of awareness of deficit. Knowledge about participants' life circumstances provides some support for generalization. Participant 2 completed a college course during the course of the study and was accepted to begin another course at a distant college site. Participant 3 obtained employment in a restaurant during the course of the study and was doing quite well at study conclusion. Participant 4 was approved to move from his group home into semi-independent living. As noted earlier, Participant 1 was retired and spent most of her time engaged in physical rehabilitation (swimming, exercising) and hobbies that she enjoyed such as knitting and gardening. Her life circumstances were mainly unchanged at the end of the study but she did report increased time on task when reading a book and reduced number of knitting errors. Participant 5 did not demonstrate any change in his life circumstances, although he reported feeling better in terms of mood and felt encouraged by participating in the study.

It is difficult to ascertain the impact of the intervention on the life circumstances of these participants. Because the study was carried out at a university and not at a hospital, participants were already established in the community and had attained some level of stable community functioning prior to entry into the study. There was also limited follow-up to determine any longer term effects.

Research Implications

The present results suggest that the targeted practice on cognitive exercises is the active ingredient in producing change on cognitive and neurophysiological outcome measures. However, this is somewhat at odds with the findings of other researchers who have detected less differential impact of the psychotherapeutic and cognitive remediation approaches (Sohlberg et al., in press, Ruff et al., 1989). Therefore, it will be informative to replicate these results in further single subject and group studies. The current study and previous studies examining this issue, highlight the importance of considering the impact of non-specific or psychotherapeutic factors in designing cognitive rehabilitation outcome research. These services should no longer be ignored when assessing the efficacy of specific cognitive rehabilitation techniques. This has been recognized by the National Institute of Health in their consensus statement for the Rehabilitation of Persons with Traumatic Brain Injury (1999). They stated that the findings from efficacy studies of rehabilitation for TBI have been limited by, among other things, the unspecified effects of social contact.

Research supporting the efficacy of attention retraining is amassing. It is becoming time to shift gears and to begin to investigate more specific questions in order to fine tune our understanding of the effects of attention retraining. For example, investigations of dose-response relationships will provide useful information. Questions such as whether it is more efficacious to administer small doses of training over a long time frame or to conduct more intensive training activities remain to be answered. Recently, a meta-analytic study queried similar issues by examining evidence relevant to intensity and onset of rehabilitation activities during the acute phase (Chesnut, Carney, Maynard, Mann, Patterson & Helfand, 1999). As alluded to earlier, information about the interaction of patient and therapy characteristics also requires further systematic inquiry. Future studies will benefit clinical practice by beginning to investigate these types of questions.

The utilization of ERPs to measure change after cognitive rehabilitation is in its infancy. Therefore, it will be important for others to replicate the findings of the current study. This study demonstrated changes in the P300 and N200 components following attention training. However, the changes were not uniform across participants and further research will help to clarify the significance of these changes. Further studies that correlate functional change with change observed using neurophysiological or functional neuroimaging will add to our understanding of the possibilities for neural recovery in adult human beings.

Clinical Implications

A number of clinical implications can be inferred from the current study. First and foremost, attention retraining tasks do appear to improve attentional functioning. This argues for the continued implementation of attention retraining programs as part of a rehabilitative program for individuals with cognitive deficits following TBI. Although the Active Control condition did not result in as many improvements on cognitive outcome measures, the value of a psychotherapeutic and educationally oriented approach in rehabilitation should not be discounted. One participant did show reduced reporting of attention problems during this condition, suggesting that implementation of compensations and strategies learned were useful. Further studies evaluating the specificity of effects of psychotherapeutically driven interventions are needed to ascertain which problematic behaviors are most improved by these types of interventions.

One important implication, alluded to earlier, is the issue of the impact of depressive symptomatology on ability to participate in a rehabilitation program. Some clinicians believe that depression is a contra-indicator for successful participation in a cognitive remediation program and that alleviation of depressive symptoms must occur first. Ruff and Neimann (1990) predicted increased emotional distress in their group of TBI patients who were participating in a cognitive remediation program. However, they found reduced emotional distress after participation in both a psychoeducational/therapeutic condition and after cognitive retraining. This is consistent with my finding that one participant showed reduced reporting of attention problems and spontaneous report of improved mood and daily functioning during APT. This suggests that depression is not a contra-indicator for participation in cognitive rehabilitation. In fact, individuals with depression may benefit from the behavioral activation offered by participation in a cognitive remediation program, whereas more traditionally oriented supportive approaches may afford the person the opportunity to over-focus on their problems. The presence of an audience, by way of the therapy group, may reinforce the maintenance of depressive and self-defeating ideation. As discussed earlier at length, feelings of self-efficacy can be fostered through participation in a program that allows for the experience of personal performance accomplishments, vicarious learning, verbal persuasion and reduction of anxious arousal. It is my belief that the APT training situation offers the appropriate environment for increasing feelings of self-efficacy.

An additional goal of the current study was to note any differences between group and individually administered APT. All participants in the study showed some improvement, regardless of whether they received APT in a group format or in a one to one situation. This finding supports administration of APT in a group setting. In a time of cost efficiency, this may allow for more individuals to have access to treatment. However, further studies are needed to replicate the usefulness of group administration of attention retraining tasks.

The interaction of patient treatment variables observed also provides information to guide clinical practice. The findings suggest that age, time since injury, and depressive symptoms, should not be factors that are used to preclude a person from participating in a rehabilitation program. Severity of injury may play a role in predicting extent of beneficial effect.

Limitations

The present study addresses a number of issues that have been raised as limitations of previous studies of the efficacy of attention retraining. The heterogeneity inherent in the population was evaluated and not ignored in this study through its single case design methodology. The issue of non-specific, psychotherapeutic effects was systematically examined and repeated baseline measurements were obtained. However, a number of limitations remain and must be discussed in considering the implications of the findings.

As noted above, ceiling effects on the Test of Everyday Attention tasks limited the ability to detect change in the different components of attention. Tasks were selected to represent sustained and selective attention, and speed of processing. However, because only two participants showed improvements on these tasks it is not possible to address issues relating to the responsivity of different attentional networks to the training tasks. This is an important area for consideration as some authors have suggested that degree of impairment in the vigilance network may impact outcome of training higher levels of attention (Sturm et al., 1997; Sohlberg et al., in press). Another difficulty related to data collection was missing data. Participants were asked to fill out a considerable amount of paper work during test sessions and did not always complete all forms requested. In addition, attention ratings were filled out by participants in their homes on a daily basis. Sometimes, they were misplaced and not returned. This resulted in inadequate data for some participants for some of the self-report measures.

The duration of the rehabilitation program employed in the current study was relatively short. Participants engaged in rehabilitation activities twice per week for one hour each time for six weeks per condition. Stronger effects may have been observed for longer or more intense training. Similarly, participants with more severe injuries may have benefitted more from a longer duration of treatment. This study is also limited by a lack of follow-up data. This precludes the possibility of drawing any conclusions about the maintenance of treatment effects. An important caveat to note is that APT materials were altered somewhat by the removal of elements that could be construed as "psychotherapeutic" or "promoting of awareness" (i.e., provision of feedback and client charting of results). Repetitive cognitive exercises were administered in isolation. This changes the nature of the APT materials as they were intended to be administered and readers must be cognizant of this difference in administration.

All studies of the efficacy of rehabilitation activities are challenged by practice effects. Each researcher is faced with the task of demonstrating that change observed on test measures is due to real change and is not a function of repeated exposure to tasks. The present study is strengthened in this regard by using three baseline measures prior to the commencement of rehabilitation activities. This allows for performance on test measures to stabilize. Alternate forms of the TEA were also employed. However, it is impossible to completely rule out practice effects as playing some role in the improvements observed.

The issue of generalizability of the improvements to real change in a person's life, although addressed, remains far from satisfactory. Ecologically valid measures of attention were used and test tasks differed from training tasks. Similarly, self-report measures were obtained on a daily basis instead of retrospectively. The difficulty lies in how to adequately measure generalization. Other authors have reported improved daily life functioning such as higher level employment or increased independence in daily living (Sohlberg & Mateer, 1987; Franzen & Harris, 1989). Two participants in the current study improved in terms of vocational and educational functioning. However, it is only possible to speculate about the role of the rehabilitation activities in these improvements due to the influence of the individual's psychosocial environment outside of the rehabilitation program. Client report of satisfaction with improvements occurring concurrently with the rehabilitation activities are perhaps the best measure of generalization at the present time.

Conclusions and Future Directions

This study was conducted to attempt to determine the specificity of the efficacy of attention retraining in producing improvements on tests of attention and neurophysiological measures, above and beyond a supportive, adjustment-oriented approach including: psychoeducation, therapeutic strategies and support, and compensatory interventions. A second objective was to determine if neurophysiological correlates of attention change after attention retraining, implicating the occurrence of underlying neural change in humans. A third objective was to determine if self-efficacy beliefs change as a function of participation in the rehabilitation program. The current study provides support for the following conclusions:

1. Changes on neuropsychological and experimental measures of attention and working memory occur after participation in attention retraining.

2. Changes in the P300 and N200 event-related potential components occur after participation in attention retraining.
3. Attention retraining activities are the "active" ingredient in producing the observed changes.
4. Feelings of self-efficacy may be increased during attention retraining and participation in the active control condition.
5. Both attention retraining and active control conditions may produce a reduction in daily self-report of observed attention problems.

This study supports the continued use of attention retraining activities with individuals with TBI who experience cognitive deficits. Additional research is needed to elucidate specific relationships between patient characteristics, intensity and duration of administration of retraining activities, and treatment approach. Furthermore, this study also supports the continued use of event-related potentials as indicators of change after attention retraining. Future research utilizing these, and other functional neuroimaging measures, will provide invaluable information about the neural processes underlying recovery after injury in living human beings. Additional information about the plasticity of the adult human nervous system has potentially far-reaching implications for learning and recovery from various brain based disorders and insults.

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Appendix A

Self-Efficacy Questionnaire

Below is a series of questions about attitudes and beliefs that people may have. Read each statement and decide to what extent it describes you. There are no right or wrong answers. Please indicate your own personal feelings about each statement below by marking the letter that best describes your attitude or feeling. Please be very truthful and describe yourself as you are, not as you would like to be.

A = Disagree strongly
B = Disagree moderately
C = Neither agree not disagree
D = Agree moderately
E = Agree strongly

____ 1. I give up easily.

____ 2. My ability to pay attention is not very good.

____ 3. Failure just makes me try harder.

____ 4. When I set important goals for myself, I rarely achieve them.

____ 5. I can pay attention long enough to finish the tasks I need to do.

____ 6. When it becomes hard to pay attention, I simply give up.

____ 7. I do not seem capable of dealing with most problems that come up in my life.

____ 8. I can focus on a task even when there is noise present.

____ 9. I can do things to make it easier for me to pay attention.

____ 10. When I make plans, I am certain I can make them work.

Appendix B

Attention Questionnaire Used For Daily Reporting

Client Name ______________________________________

Rater's name and relationship to client (if applicable) ___________________

Date ____________________

Please answer the following questions about your (or __________'s) attention as it applies to every day functioning by ticking the box which offers the best description.

Description	**Not a problem or no change from before**	**Only gets in the way *on occasion* (less than once per week)**	***Sometimes* gets in the way (about 1-3 times per week)**	***Frequently* gets in the way (is a problem most days)**	**Is a problem *all the time* (affects most activities)**
1. Seem to lack mental energy to do activities					
2. Am slow to respond when asked a question or when participating in conversations					
3. Can't keep min on activity or thought because mind keeps wandering					
4. Can't keep min on activity or thought because mind feels "spacey" or "blank"					
5. Can only concentrate for very short periods of time					
6. Miss details or make mistakes because level of concentration decreased					
7. Easiliy get off track if other people milling about nearby					
8. Easily distracted by surrounding noise					
9. Trouble paying attention to conversation, if more than one other person					
10. Easily lose pace if task or thinking interrupted					

11. Easily overwhelmed if task has several components					
12. Difficult to pay attention to more than one thing at a time					

Appendix C

Consent Form Utilized in this Study

UNIVERSITY OF VICTORIA
DEPARTMENT OF PSYCHOLGY
P.O. BOX 3050, VICTORIA, B.C.
V8W 3P5
TEL (250) 721-7525/ FAX (250) 721-8929

INFORMED CONSENT TO PARTICIPATE IN A RESEARCH PROJECT

This research project is studying the effectiveness of different approaches to the rehabilitation of attention problems after traumatic brain injury. It is being carried out by Louise Penkman, M.Sc., graduate student, under the supervision of Dr. Catherine Mateer, Registered Psychologist, at the University of Victoria. You will be assigned to one of two rehabilitation groups. If you are in group one, you will meet with the rehabilitation therapist to participate in attention rehabilitation. If you are in group 2, you will meet with two other people who have sustained a traumatic brain injury, in addition to the rehabilitation therapist. You will meet twice per week for one hour each time for six weeks. After this six week phase, you will participate in a second group with six other people who have sustained a traumatic brain injury and the rehabilitation therapist. This will also last for six weeks and will take place twice per week for one hour. In addition, before the rehabilitation starts you will be coming to the University to participate in some testing. The testing will take place once every two weeks for six weeks before the rehabilitation starts and again every two weeks throughout the rehabilitation process. The testing will take approximately two hours each time. Testing will involve doing activities like searching for little pictures as fast as you can and counting beeps. You will also fill out some questionnaires that ask you about your attention. You will also receive an electroencephalogram (EEG). This is a recording of brain activity. You may observe a very mild skin irritation where the electrodes contact your skin.

It is hoped that the rehabilitation procedures utilized for this study will be helpful for people recovering from a brain injury. However, there is no guarantee that the rehabilitation offered in this study will help you with any problems that you are experiencing.

Your participation is completely voluntary and you can withdraw from the study at any time, without explanation. Should you withdraw from the study, data already collected can only be used with your permission. You have the right to have your data destroyed. You have the right to refuse to answer any questions you do not wish to answer. If you finish the study, you are entitled to a $100.00 honourarium.

Any data collected in the study will remain confidential; interview results and questionnaires will be kept in a locked cabinet in a locked office. Relevant information will be transcribed from the initial interview and will be kept separate from your name. Original notes taken during the interview with you will be destroyed. **Your name will not be attached to any papers or published results** based on this research and **no one will be able to identify your information** because code numbers will be used instead of your name. Only the researcher will have access to the data. Any consent form that you sign will be stored separately from coded data so the two cannot be connected. EEG data will be stored on Zip discs in a locked room and will also be numerically coded. You will not be anonymous when you participate in the rehabilitation groups.

The results of this study will be used for Louise Penkman's doctoral dissertation. In addition, the findings may be published in a scholarly journal. The data will be destroyed after 7 years, according to the guidelines of the Canadian Psychological Association.

The data that will be collected in this research project is being sought on the basis that the data provided by you will be kept confidential by the researchers and the University. If a court or tribunal issues a subpoena or lawful demand seeking production of confidential data provided by you, the researchers will assert that the data is confidential and claim that the data is privileged from production or disclosure. If this occurs, the court will determine whether or not the data must be disclosed.

Whether you participate or choose not to participate will have no bearing on your medical treatment at the Gorge Road Hospital or at any other medical facility. Information obtained during this study will not be released to staff at the Gorge Road Hospital without your written consent.

I can be reached at the University of Victoria at 721-7560. Dr. Mateer can be reached at 721-8590.

Signature of Participant:
Date:

Signature of Researcher:

Appendix D

Psychoeducational/Therapeutic Materials used in the Active Control Condition

What is a brain injury?

You've been in a car accident, or perhaps you got hit really hard playing hockey, or you fell from a ladder. Your physician has told you that you have a brain injury. But what does that mean? Is it like spraining your ankle? Is it swollen and will applying ice help?

The brain can be injured in different ways and it recovers differently for different people. It is a very complicated organ, the most complicated one that we possess, but we are learning more and more about how it works and what happens when it is injured.

Probably the most common kind of brain injury is known as ***Diffuse Axonal Injury***. Sounds weird, but this is what it means. Our brain is made up of millions of nerve cells. Nerve cells have a cell body and legs (they kind of look like an Octopus). The legs are short on one side and they receive messages; these are called ***dendrites***. They also have very long legs that send out messages. These are called ***axons***; they are responsible for the high speed communication in our central nervous system. For example, when someone accidentally leaves the burner on and you find out by touching it, you pull your hand away immediately before it gets too badly burned. Sometimes, you pull your hand away so quickly you don't even realize that you have done so. Well, that is because of the super-fast communication of your nerve cells, thanks to their axons.

When your brain moves very rapidly inside your skull (for example, when you are in a car accident and your car comes to a very rapid halt before you and your head do), these very important axons can be damaged. Sometimes they are stretched and sometimes they actually tear. When this happens some of the axons die. This often happens in many different areas of the brain, although some areas tend to lose more axons than others. This is why it is called Diffuse Axonal Injury. You can't see this type of damage, and neither can most of the fancy medical imaging machines. It is only visible by microscope. With a DAI type of injury you might have trouble with concentration and speed of thinking.

Your brain can also bruise, sort of like the rest of your body. The medical name for bruise is ***contusion***. You might have heard the doctor say that there is a small contusion that showed up on an MRI scan, for example. A contusion often happens when your brain is hit really hard in one spot, like if you are assaulted, or something falls on your head. Sometimes you actually get two bruises, one at the point where you were hit and one at another area of your brain where it slammed against your skull when you were hit. For example, if you fall down and hit the back of your head you might develop a contusion there and also at the front of your brain where your brain bounced up against your skull. Your skull is quite bony and sharp in places. Particularly, in the frontal and temporal (around the ears) areas. Therefore, these are the most common places for contusions.

You can also get other types of bleeding in your brain when you are injured. This can happen if little blood vessels are torn and you may get small hemorrhages. Your brain is covered with thin coverings and bleeding can occur in between the coverings too.

Now that we've discussed how the brain gets injured, let's talk about how it recovers, because it always does to some extent. Brain injuries don't get worse!!

When you first injure your brain, you might have felt dazed and out of it, you might even have passed out, just briefly or for a longer period of time. This is when your brain has sustained enough damage to temporarily shut it down. For some people, they may have been awake for days after the accident but they don't remember this time at all. It's like they have lost some memories. This is called post-traumatic amnesia or PTA. For some people, loss of memories is due to lots of pain medications. For others, it is because their brain was not working properly and not storing any new memories at this time, although they may have been acting quite normally. When they start remembering things again, their brain is starting to recover.

Research indicates that the most rapid recovery occurs in the first six months after the injury. This is when bleeding and other problems are resolving and parts of the brain that were only temporarily damaged begin to work properly again. Pretty rapid recovery continues until about 2 years after the injury, although it is not quite as fast as for the first six months. This does not mean that recovery stops after two years but changes are smaller and less noticeable and may take more time. The brain is very complicated and likely keeps healing for many years. After the first year, it is good to get into some sort of rehabilitation program. It seems that the brain responds to a good work out just like an injured body part would!!

Memory

To remember something is a multi-step process. We think it goes something like this:

1. Before you can learn and remember something you must first attend to it.
2. Then you need to apply strategies to make it "stick" in your memory (i.e., rehearsing the phone number).
3. Once it is in there, you need to be able to retrieve it later.

Numerous brain structures are thought to be involved in memory. An area deep inside your temporal lobes (near your ears) is thought be critical for storing new memories. Older memories are believed to be stored throughout your brain. The frontal lobes are thought to be involved in organizing the search for that information when you need it later. Again, the area in your temporal lobes is also involved in reactivating your older memories.

Memory can be impaired by bruising to the temporal and frontal areas. It can also be impaired by diffuse damage that stretches and tears important pathways that transmit information.

Why is memory sometimes impaired after a brain injury?

1. **Thinking is slower**

- speed of learning decreases, so learning new information takes more time
- speed of recall decreases so it takes longer to retrieve information already stored in our memory

BE PATIENT, IT WILL COME TO YOU…DO LOTS OF REVIEW WHEN YOU WANT TO REMEMBER SOMETHING LATER

2. **Paying attention is more difficult**

- concentration problems makes it harder to get the information in
- distractions are more difficult to ignore
- interruptions make it harder to remember

IMPROVE YOUR ATTENTION THROUGH TARGETTED PRACTISE
USE COMPENSATIONS - TURN DOWN BACKGROUND NOISE WHEN YOU ARE LISTENING TO SOMETHING YOU ARE TRYING TO REMEMBER

3. **Effective memorization strategies are used less**

- before a head injury you naturally use things like visualization, associations, and organization to help you to remember - the frontal lobes help us do this
- after an injury this sometimes doesn't happen automatically anymore and we have to remember to use these memory tricks

- slowing also makes it harder to use these tricks quickly

SLOW DOWN AND TAKE THE TIME YOU NEED

4. **Recall requires more memory cues**

- again this is the job of the frontal lobes, they help us to search our memory in order to recall the information we are looking for.

STAY CALM WHEN TRYING TO REMEMBER AND THINK OF ALL THE THINGS ASSOCIATED WITH WHAT YOU ARE TRYING TO REMEMBER - THIS MAY TRIGGER YOU TO REMEMBER THE SPECIFIC WORD YOU ARE LOOKING FOR - AGAIN, GIVE YOURSELF TIME

Other Factors Affecting Memory Problems:

Attitude - people tend to become very anxious when they cannot remember something and anxiety interferes with remembering. Memory problems may occur due to a self-fulfilling prophecy caused by a belief that memory has been irreversibly damaged. If you say "I just can't remember" you might just stop trying and miss some opportunities to successfully remember things.

Disuse - memory gets rusty (use it or lose it). Try to challenge yourself in various ways.

Diet - inadequate diet can contribute to memory problems.

Depression - thinking slows with depression and combines with the slowness caused by the brain injury. A person who is depressed may also not feel well enough to pay attention in order to remember.

Attention problems - see above

Anxiety

How to improve/compensate for your memory

REDUCE ANXIETY - relaxing increases ability to pay attention and hence remember!

- engage in positive relaxation
- give yourself a break and don't be self-critical when you forget - think positive!

CHOOSE WHAT TO REMEMBER AND WHAT TO FORGET

- It's okay not to remember everything

STRENGTHEN YOUR MEMORY SKILLS

- use internal and external strategies

Internal Strategies:

- rote repetition
- verbal elaboration
- mental imagery
- association
- make up rhymes (I before E except after C) mnemonics
- improve attention
- be multi-sensory - see, touch, listen, taste
- read more than once, out loud
- keep your mind active

External Strategies:

- have structure and organization in your life - have a place to keep your keys so you don't lose them!
- keep a calendar, day-timer etc.
- write things down! Use notes - this will also reinforce internal strategies
- use lists
- use other people
- use alarms or timers where appropriate

Attention Compensations

Compensations are useful ways to deal with problems while they are recovering. They are also helpful for those problems that do not seem to be getting any better.

1. Reduce distractions
   - turn off radios, TVs, etc. when concentrating (i.e., to read) or when having a conversation.
   - Use earplugs.
   - close curtains so you are not tempted to stare out the window at all of the interesting people going by!!
   - De-clutter your environment - visually and otherwise.

2. Avoids crowds
   - plan your day so you can shop and/or drive during the "off" hours (e.g., don't do groceries on Saturday afternoon).
   - if you must be in a crowded situation, don't require yourself to do something that demands a lot of concentration.

3. Manage fatigue
   - As soon as you begin to feel overwhelmed (or overloaded) take a short break - the sooner the break, the faster you will be able to get back to what you were doing and be effective.
   - Be persistent and keep coming back to what you were doing.
   - Do not push yourself!

4. Avoid interruptions
   - Turn off your ringer or use an answering machine when you are trying to get something done.
   - Use a "do not disturb" sign if you live in a busy household.

5. Get enough sleep
   - You may need more sleep now than you used to - make sure you get enough, take naps!!
   - Get medical help if this is a problem.

6. Get some exercise
   - Research is now beginning to show that a more efficient body also means a more efficient brain.
   - Regular exercise is good for your thinking skills!

7. Ask for help

- This can sometimes be one of the hardest ones of all.
- Tell people that you trust about what you are struggling with and enlist their help - have them remind you of things you could be doing to help yourself (such as those listed here).
- Ask people to talk a little slower, repeat things, turn off the TV etc.

8. Make changes in your environment
    - Put important things in very obvious places so that you don't misplace them.
    - Simplify and de-clutter your environment if you have difficulty with *selective attention* - screening out unwanted information - make the things you want to pay attention to more salient.
    - If you have problems with *arousal* or *sustaining your attention* change your environment so that you can be more interested in what you are doing (e.g. add some novelty to what you are doing).

9. Break down tasks into smaller parts
    - This helps tasks to appear less overwhelming
    - It also enables you to learn the different parts so well they may become automatic and therefore easier to do.

10. Talk to yourself
    - This sounds corny but it works. When we are having difficulty doing something "talking ourselves through it" is often helpful.
    - Remind yourself to pay attention, instruct yourself on how you are going to deal with a difficult situation.

11. Monitor yourself
    - Keep track of your behavior and note what you like and what you think needs changing.

Restructuring your thinking/feeling/responding to events in your life

- Learning about cognitive behavioral therapy is like learning the ABCs (literally)

A = Antecedent event

B = Belief

C = Consequence

Here is an example:
A = Lawyer calls and says you have to have another set of neuropsych testing done.

B = Your belief is that this is all a waste of time and your lawyer does not really know what he/she is doing.

C = You get angry and upset and resent the entire process of the assessment and generally feel really bad about it.

- How we think impacts how we feel so if we target what we can control (our thoughts) as opposed to what we can't control (A = the actions of others, events in our lives) we can gain some control over how we feel.

- Turn irrational or negative beliefs into more positive or reasonable ones.

Some common thought distortions:

- Personalization
- Magnification
- Minimization
- Catastrophization
- Mind Reading
- Black and White thinking

Common Irrational Beliefs Following Head Injury with Rational Challenges

1. **Irrational statement:** "I should be able to do this now – I could before."

Rational Challenge: "Whether I like it or not, I can't do some things as well as I could before my injury. It would be a good idea to take a fresh look at what my actual abilities and deficits are right now."

2. **Irrational statement:** "I shouldn't have to live this way" or "It's not fair that this happened to me"

Rational Challenge: "what happened to me wasn't fair and there's no reason I should like it. However, the world isn't fair and my only options are to make the most of what I can with what I've got or to give up."

3. **Irrational Statement:** "My injury was a punishment."

Rational Challenge: "I was imperfect before my injury - just like everyone else. By my injury was not fair. I am an okay person who didn't deserve bad things, but bad things happen to good people."

4. **Irrational Statement:** "Now that I've been injured and have suffered, I'm going to wait until I've gotten everything I have coming to me before I make any plans" or "the owe me."

Rational Challenge: "No matter what I get (financially or otherwise) no one can make it like my injury didn't happen. MY life will be most satisfying and most under my control if I select some meaningful and realistic goals and work hard to achieve them." or "It makes sense for me to pursue the available channels for appropriate compensation, but to place my emphasis on goals within my control."

5. **Irrational Statement:** "I can't do anything right anymore" or "I'm no good anymore."

Rational Challenge: "I can't do some things as well as before but I have proven I still have some capabilities and some potential for improvement. I can learn to accept myself as I am now and maybe in the future by changing my expectation of myself and my ways of measuring self worth."

6. **Irrational Statement:** "I don't have any problems - other people are just picking on me."

Rational Challenge: "Of course, everyone has some imperfections. In my case people who know me pretty well and care about me have identified some changes in me from before my injury. If I remind myself that they are trying to help and that changes and difficulties are often easier for others to see than for the person themselves, I can take better advantage of their observations."

Balanced Perspective - Personal

1. This week, I am encouraged by my success (or progress) in ____________________
____
____
____, but I am discouraged (or frustrated or saddened) by my continuing problems with
____
____

1. This week, I am encouraged by my success (or progress) in ____________________
____
____
____, but I am discouraged (or frustrated or saddened) by my continuing problems with
____
____

2. This week, I am encouraged by my success (or progress) in ____________________
____
____
____, but I am discouraged (or frustrated or saddened) by my continuing problems with
____
____

Problem Solving Skills

- Getting too emotional about your problems can reduce your ability to think effectively!!

Steps to good problem solving:

1. Define the problem
    - describe the problem accurately and in detail
    - view yourself as having some responsibility and some control in the situation
    - have you encountered a similar problem in the past? What worked? What didn't work? Do you know someone else who has encountered a similar problem?

2. Generate alternate solutions
    - Do not discard or judge ***any*** of your solutions as stupid or unworkable - some of the best ideas come from wide open brain storming sessions where many seemingly silly ideas are suggested.

3. Decide on the best solution
    - anticipate the possible outcomes for the different solutions - guess what might happen.
    - perform a cost-benefit analysis.

4. Implement your solution
    - If it doesn't work, reward yourself for trying and then go back up to your alternate solutions and try to choose another alternative - OR - evaluate what might have gone wrong in your first attempt (recycle your original idea).

Note. Materials for discussing emotional response to injury, anger and depression, and headache management were taken from the web page www.tbiguide.com.

Appendix E

Hand-outs used for Increasing Self-Monitoring and Awareness during Active Control Condition

Individualized Attention Problem List

In the space provided below describe the five most frequent and frustrating breakdowns in your attention ability. The first line has been filled out with an example description.

Describe Attention Breakdown (including setting and approx. frequency)	**What do you do when it occurs?**
Example: I cannot concentrate when I am preparing dinner because the noise from my kids playing and even noise in the next room distracts me. I forget ingredients or parts of the meal and usually feel totally frustrated during this time. This happens at every dinner.	I often yell or blow up at the kids or cry while I am cooking. Sometimes I just give up and make something simple like sandwiches.
1.	
2.	
3.	
4.	
5.	

Attention Success Log

Name: ______________________________

DATE/TIME	Describe attention success	Why do you think you were successful? (e.g., list strategies)

Attention Lapse Log

Name: ______________________________

DATE/TIME	Describe lapse in attention	What did you do (or could you have done) to manage lapse?

VITA

Surname: Penkman Given Names: Louise Carol

Place of Birth: Billinge, England
Date of Birth: March 27, 1970
Status: Canadian Citizen

Educational Institutions Attended:

University of Victoria	1994 to present
University of Ottawa	1989 to 1993

Degrees Awarded:

B.A. (Honours)	University of Ottawa	1993
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Honours and Awards:

Sara Spencer Foundation Research Fellowship	1998
Natural Sciences and Research Council PGS B Fellowship	1996 to 1998
Norma Wilson Graduate Bursary	1995
Annie Greskiw Graduate Award	1995
Vancouver Foundation Medical Services	
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Publications:

Sohlbeg, M.M., Mateer, C.A., Penkman, L., Glang, A., & Todis, B. (1998). Awareness Intervention: Who Needs It? Journal of Head Trauma Rehabilitation, 13, (5), 62-78.

Johnson, S.A., Penkman, L.C., Strauss, E.H.S., Sherman, E. & Spellacy, F. (1998) Psychiatric Confounds in the Assessment of Traumatic Brain Injury. Poster presented at American Psychological Association, San Francisco, CA.