Evaluation of Attention Process Training III in persons with traumatic brain injury

Caitlin Sears

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Committee:

Kristie Spencer

Patricia Dowden

Laura Hardy

Kathryn Yorkston

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Abstract

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Caitlin Sears

Chair of the Supervisory Committee:
Kristie Spencer, Ph.D., CCC-SLP
Speech and Hearing Sciences

Abstract:

Primary Objective: Attention deficits are common following traumatic brain injury (TBI). Studies of rehabilitation of attention have identified factors that comprise successful treatment programs. To date, there have been no experimental studies to determine the effects of the most recent version of Attention Process Training (APT-3). This study aimed to assess treatment outcomes of APT-3 across levels of disability in individuals with TBI.

Research Design: Pre-experimental single subject A-B-A design.

Methods and Procedures: The participant completed two 60-minute sessions weekly for 7 weeks. Treatment sessions included specific attention exercises, training metacognitive strategies, and identifying and discussing functional goals.

Main Outcomes and Results: Progress was made in each domain of intervention. Treatment results were corroborated by notable gains in comprehensive standardized measures of attention as well as participation-level questionnaires and semi-structured interviews. These findings provide support for a combined compensatory-restorative model of cognitive rehabilitation.

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INTRODUCTION

Each year, 1.7 million Americans sustain a traumatic brain injury (TBI) (Faul, Xu, Wald, & Coronado, 2010). Of those, 1.365 million are treated and released from an emergency department (Faul et al., 2010). Cognitive-communication disorders are a lasting effect in the majority of individuals who have had a brain injury (MacDonald, 2010). This equates to approximately 5.3 million Americans currently living with some degree of cognitive-communication disorder sustained from a TBI (Stierwalt & Murray, 2002). The American Speech-Language-Hearing Association (2007) defines a cognitive communication disorder as follows:

> *Cognitive-communication disorders encompass difficulty with any aspect of communication that is affected by disruption of cognition. Communication includes listening, speaking, gesturing, reading and writing in all domains of language (phonologic, morphologic, syntactic, semantic and pragmatic). Cognition includes cognitive processes and systems (e.g. attention, memory, organization, executive functions). Areas of function affected by cognitive impairments include behavioral self-regulation, social interaction, activities of daily living, learning and academic performance and vocational performance.* (para. 2)

According to ASHA (2007), all components of cognitive-communication deficits following a TBI fall within the scope of practice of a speech language pathologist.

Attention deficits are one of the most debilitating cognitive consequences of TBI. Often, attention impairments remain as the most lasting cognitive effect after the acute phase of a TBI and affect an individual's ability to return to their previous functioning (Pero et al., 2006). Attention is generally defined as a system of cognitive processes that allow us to focus on a chosen stimuli or process under varying levels of environmental distractions

(Sohlberg & Mateer, 2010). Attention is comprised of an intensity component and a selectivity component (Pero et al., 2006). Intensity refers to the processes responsible for attending over time, while selectivity refers to the components responsible for choosing among competing stimuli. Both processes are often affected following TBI.

The purpose of this study is to investigate the efficacy of a treatment for attention deficits (*Attention Process Training III* or APT-3) for one or two individuals who have sustained a TBI. A summary of current models of attention will first be provided, followed by a description of models of cognitive rehabilitation. Next, formal attention training programs will be summarized with a review of the current state of evidence for those rehabilitative programs.

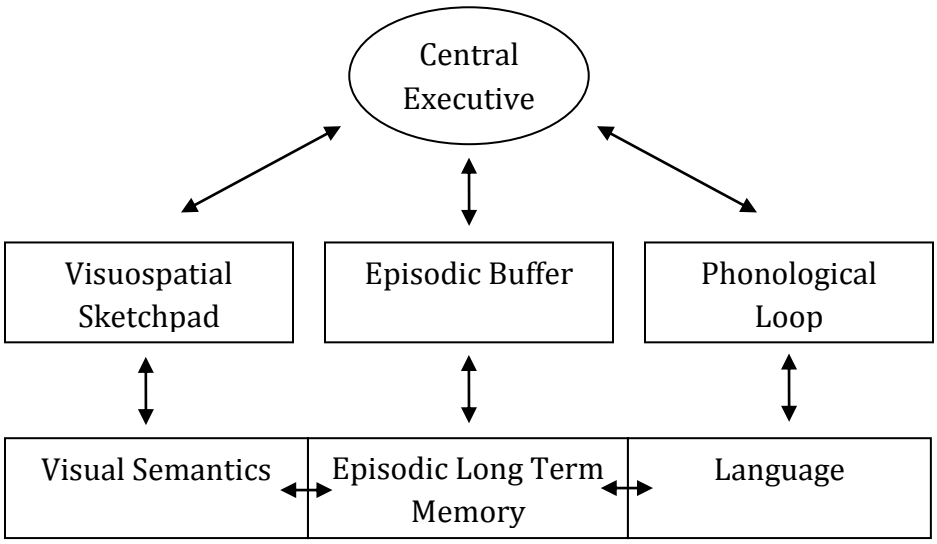
Models of Attention

Many frameworks for understanding attention have been proposed over the years. They include models based in cognitive processing, factor analysis of psychometric tests, neuroanatomic theories, and clinically based models (Sohlberg & Mateer, 2010). Understanding models of attention is essential to designing and implementing a theoretically grounded rehabilitative program.

Baddeley is best known for his models of working memory, yet he also was instrumental in defining the concept of the central executive control of attention (Baddeley, 2001; Sohlberg & Mateer, 2010). His most recent model identifies the central executive as the attentional control system that directs our ability to focus, divide, and switch attention (Baddeley,

2001; Sohlberg & Mateer, 2001). It is a system that has little capacity for storage of information, but rather regulates selection and focus of thoughts or actions. As shown in Figure 1, the visuospatial sketchpad and phonological loop are responsible for input of visual/spatial and acoustic/verbal sensory information, respectively, into this cognitive processing system (Baddeley, 2001). In isolation, these subsystems, along with the central executive, allow for attentional control of immediate sensory input, but would not allow for integration with previously learned schema (Baddeley, 2001). As such, the episodic buffer was added to the processing system. The episodic buffer allows for integration of novel stimuli with stored stimuli, and provides a small amount of episodic storage to allow for simultaneous inputs of multiple stimuli (Baddeley, 2001). This complete system provides a model of attentional processing that allows for integration of stimuli from short term and long term memory, as well as active processing of stimuli to allow for intentional selection.

Figure 1. Baddeley's current model of the central executive (2001). The lower box depicts the interactions of the attentional system with the external language, visual semantics, and long term memory systems.



A second cognitive processing model for attention was described by Norman and Shallice in 1980. Their model is comprised of hierarchically organized successive levels of advanced processing: cognitive units, schemas, contention scheduling, and supervisory attentional system (Burgess & Alderman, 1990). As described by Burgess and Alderman (1990), cognitive units include processes that are generally associated with neuroanatomical structures, such as language, motor programs, or visual input. Schemas are defined as automatic and over learned thoughts or actions that are triggered through sensory input or other schemas. Contention scheduling occurs when multiple schemas could be used to fulfill an intended action or thought. The most efficient schema to complete the task is chosen in rapid succession with little to no conscious decision making. Execution of both schema and contention scheduling require an intensity component of attention to maintain selection of a given cognitive process over time. The most advanced process in Norman and Shallice's cognitive processing model is the supervisory attentional subsystem (SAS). This system is responsible for overriding schemata and contention scheduling during intentional decision making or during interference to the intended schema (Baddeley, 2001; Burgess & Alderman, 1990). The SAS is used to intentionally integrate novel stimuli from the environment with past knowledge from routine schemata to create a novel reaction. This theoretical model aligns with that of Baddeley (2001; Burgess & Alderman, 1990). The SAS requires a selectivity component and an intensity component of attention in order to maintain selection to a schema while overriding the automatic plan. In other words, when presented with a novel situation (e.g. a truck stopping quickly in front of a driving car), one must select an alternative response from episodic long term memory (e.g. engage brakes rather than continue driving) while maintaining attention to the original

stimuli (e.g. the routine of driving the car). Given the nature of the SAS to supersede overlearned behaviors, this subsystem is essential for managing stimuli that does not yet have a rote schema. Therefore, when damage occurs to the frontal lobe, which is most closely associated with these processes, individuals experience difficulty redirecting attention or perseverate on irrelevant input as a result of impaired attention (Baddeley, 2001).

Factor analytic models of attention utilize factor analysis on psychometric testing to divide attention into subcomponents (Zomeren & Brouwer, 1994; Sohlberg & Mateer, 2001, 2010). Mirsky, Yardley, Jones, Walsh and Kendler (1995) utilized this method to analyze the psychometric properties of attention in individuals with schizophrenia (Sohlberg & Mateer, 2010). They identified subcomponents of attention to be focus-execute, sustain, encode, and shift (Mirsky et al, 1995; Sohlberg & Mateer, 2010). Other factor analytic models include those of Standkov (1983, 1988) and of De Jong (1991) who found weak evidence for categorization of attention (as cited in Zomeren & Brouwer, 1994). Thus, factor analytic models have not been cohesive in defining a model of attention.

Posner and Rothbart's (2006) neuroanatomic model of attention describes a system of anatomic areas responsible for a discrete attentional processing system. This model is based on Hebb's (1958, 1966) work, and was expanded with the development of neuroimaging and genetic science (as cited in Posner & Rothbart, 2006). The development of the neuroanatomical system is influenced by genetic coding and experiences with the outside world (Posner & Rothbart, 2006). It has been observed that genetic coding can

specify physical manifestations in the anatomical structures of the brain. Normal variations affect the efficiency of functioning of the neuroanatomical system. The genetic predisposition for neuroanatomical functioning is then affected by the environmental stimulations placed on an individual, as the brain's plasticity is continually influenced by stimuli. Posner and Rothbart's model of attention consists of: alerting, orienting, and executive control. According to the authors, alerting is responsible for selecting and maintaining vigilance to stimuli. The neuroanatomical structures associated with alerting include locus coeruleus, right frontal lobe and the parietal cortex. The associated neurotransmitter is norepinephrine. Orienting refers to the process of selecting a given sensory stimuli to attend to. Neuroanatomically, the structures involved include the superior parietal region, the temporal parietal junction, the frontal eye fields, and the superior colliculus. Acetylcholine is the modulating neurotransmitter of this system. The final subsystem, executive control, is responsible for resolving conflict amongst incoming stimuli and intended responses. Posner and Rothbart (2006) have identified the anterior cingulate, basal ganglia, and lateral, ventral, prefrontal cortex as the neuroanatomical structures associated with this subsystem, while dopamine is considered the neurotransmitter modulating this subsystem. This theoretical model also associates attentional control with orientation to and selection of emotional and behavioral response, suggesting the attentional system is responsible for control of those functions (Posner & Rothbart, 2006).

Sohlberg and Mateer (2001) described a model of attention that is based in cognitive theories and can be used as a clinical framework for the evaluation and treatment of

attentional impairments. It was derived, in part, from the observation of the rehabilitation of individuals with TBI (Sohlberg & Mateer, 2010). The model consists of five components of attention: focused attention, sustained attention, selective attention, alternating attention, and divided attention (Sohlberg & Mateer, 1987, 2001, 2010). As described by Sohlberg and Mateer (2001), focused attention is the basic response to external or internal stimuli. The stimuli may be auditory, visual, tactile, or cognitive. It is often acutely disrupted after a TBI, but it is restored quickly in most patients (Stierwalt & Murray, 2002). Sustained attention is the maintained response to a stimulus presented continuously. Sohlberg and Mateer (2001) describe two components of sustained attention: vigilance and working memory. Vigilance is defined as the continual response over time and working memory refers to the mental control necessary to hold and manipulate information. Selective attention is the ability to select and attend to a chosen stimulus in the presence of competing internal or external stimuli. Alternating attention refers to the ability to control attentional allocations in order to switch between dissimilar cognitive tasks. Finally, divided attention is the ability to simultaneously produce competing responses to multiple cognitive inputs. Sohlberg and Mateer (2001) acknowledge that although a cognitive processing model may describe divided attention as extremely rapid alternating attention, their clinical model separates the processes to validate the clinical significance of rehabilitating this skill intentionally. After a TBI, sustained, selective, alternating or divided attention may show signs of impairment for years after onset, especially during cognitively complex tasks (Stierwalt & Murray, 2002). A method for predicting the type and severity of damage to the attentional system has not yet been identified, as the results of a TBI produce unpredictable heterogeneity of symptoms (Stierwalt & Murray, 2002).

The theoretical model of attention that provides the basis for APT-3 is Sohlberg and Mateer's clinical model (2010). Several changes were made to the model to account for uncertainties in the theoretical frameworks surrounding working memory and divided attention. In Sohlberg and Mateer's model (2001, 2010), working memory was considered a component of sustained attention. During the development of APT-3, working memory was considered separately from sustained attention and treatment exercises were designed to specifically address working memory. This was done to emphasize the importance of working memory as an executive control of attention (Sohlberg & Mateer, 2010). The second theoretical change was the removal of divided attention as a unique aspect of attention. Divided attention has not been differentiated from rapid alternating attention, and as such, tasks specific to divided attention were removed from the development of APT-3 (Sohlberg & Mateer, 2010). A third change in the development of APT-3 was the addition of suppression as an executive control of attention. Suppression is the ability to simultaneously select a target response while inhibiting an automatic response. In summation, the clinical attention model used for APT-3 included the following components: Basic Sustained Attention and Executive Controls composed of working memory, selective attention, suppression, and alternating attention (Sohlberg & Mateer, 2010).

Models of Cognitive Rehabilitation

In a clinical practice guideline for cognitive rehabilitation, Cicerone et al. (2000) identified four approaches to rehabilitation:

> *(1) Reinforcing, strengthening, or reestablishing previously learned patterns of behavior; (2) establishing new patterns of cognitive activity through compensatory cognitive mechanisms for impaired neurologic systems; (3) establishing new patterns of activity through external compensatory mechanisms such as personal othoses or environmental structuring and support; and (4) enabling persons to adapt to their cognitive disability, even though it may not be possible to directly modify or compensate for cognitive impairments, in order to improve their overall level of functioning and quality of life* (p. 1597).

The first of these approaches to cognitive rehabilitation reflects a restorative approach, in which neuronal re-growth of damaged neurons is anticipated (Coelho, DeRuyter, & Stein, 1996; Robertson & Murre, 1999). The second and third approaches both represent compensatory rehabilitation approaches. Compensatory rehabilitation can either refer to internal or external compensatory strategies. Internal compensatory strategies aim to reorganize cognitive functioning by rerouting the neural networks to bypass damaged neurons (Coelho, DeRuyter, & Stein, 1996; Robertson & Murre, 1999). That is, if neural networks responsible for a particular neuropsychological process are sufficiently damaged and restoration of that same process is not possible, alternative neuropsychological processes may be utilized to elicit the same behavior. For example, if the neural networks supporting sustained attention are damaged, one might rely on repeated internal cuing to the stimuli to override the loss of sustained attention. The behavior observed is perceived to be the same as the non-brain-damaged individual who is able to sustain attention, but the process has been compensated neurologically (Robertson & Murre, 1999). This view is rooted in Luria's theories (1963; Luria, Naydin, Tsvetkova, & Vinarskaya, 1975) which suggest that neurons outside of the hippocampus are not capable of regeneration, and therefore reorganization of networks is the only plausible cortical restitution following

damage (as cited in Robertson & Murre, 1999). External compensatory strategies, on the other hand, may consist of physical aids (e.g., a day planner to support executive functions) or external behaviors (e.g., requests for physician to write out recommendations).

Proponents of restorative strategies believe that neuronal regrowth occurs through activation of neural circuitry as a result of the brain's plasticity (Coehlo et al., 1996; Robertson & Murre, 1999). Neural plasticity is experience-dependent, and as such, experiences can be presented to intentionally support restoration (Roberson & Murre, 1999). Restoration and brain plasticity are possible through the same mechanism of neural regeneration that allows for new learning, and therefore follows similar growth patterns that were described by Hebb (1949) in his learning theories (as cited in Robertson & Murre, 1999). Hebbian learning states that synaptic connections are created, and perhaps restored, through simultaneous activation of pre- and post- synaptic neurons. This theory suggests the possibility of individualization of learning and relearning based on experiential episodes (Posner & Rothbart, 2006; Robertson & Murre, 1999). The possibility for restitution of neuronal networks is dependent on the size of the lesioned circuit and the level of connectivity (Robertson & Murre, 1999).

Although Stathopoulou and Lubar (2004) have documented that neurological changes can be evidenced on EEG following cognitive therapy, identifying restorative versus compensatory neuroregeneration is nearly impossible using behavioral assessments. This differentiation would require an understanding of the neural organization of an individual before and after the onset of the injury (Robertson & Murre, 1999). In actuality, a combined

approach of (presumed) restoration and compensation is commonly accepted as the method for rehabilitating individuals with TBI (Gordon et al., 2006) and attentional control in particular (Rees, Marshall, Hartridge, Mackie, & Weiser, 2007; Roberston & Murre, 1999, Coelho et al., 1996). The APT-3 treatment paradigm facilitates both restoration and compensation of cognitive components of attention.

Attention Training Programs

Models of attention and cognitive rehabilitation have provided a foundation for the development of several formal attention training programs, highlighted in Table 1. These impairment-based rehabilitation approaches are often supplemented with participation- and activity-level approaches, such as environmental supports, external aids, and psychological services (Sohlberg & Mateer, 2001).

There are many similarities among the attention training programs listed in Table 1. Many programs include tasks to address specified subsystems of attention, dependent on the espoused attention theory. The majority are organized into a hierarchy of tasks to sequentially and systematically increase the difficulty of treatment (Stierwalt & Murray, 2002; Fasotti et al., 2000). Some of the treatment programs, such as Attention Training Technique, have prescribed activities, while others, such as Time Pressure Management or the Seven-Level Model of Attention Training, include only suggestions for activities (Wells, 1990 as cited in Riccio, 2004; Fasotti et al., 2000; Stierwalt & Murray, 2002). Many attentional rehabilitation programs are now computerized, including APT-3, Attentional Training System, Orientation Remedial Module, and Bracy Cognitive Rehabilitation

Program, despite summative findings from MacDonald and Wiseman-Hakes (2010) that suggest computer training for attention is not well supported by evidence unless it includes functional goals and clinician input (Sohlberg & Mateer, 2010; Riccio & French, 2004).

Table 1. Summary of Attention Training Programs.

Program	**Authors**
Seven-Level Model of Attention Training	Parente & Anderson-Parente, 1991 (as cited in Stierwalt & Murray, 2002)
Brainwave-Revised	Malia, Bewick, Raymond & Bennet, 1997
Time Pressure Management	Fasotti, Kovacs, Eling, & Brouwer, 2000
Attention Training System	Gordon Systems, Inc., 1987
Pay Attention!	Thomson & Kerns, 2005
Attention Training Technique	Wells, 1990
Orientation Remedial Module (ORM)	Ben-Yishay, Piasetsky, & Rattok, 1987 (as cited in Riccio, 2004)
Bracy Cognitive Rehabilitation Program	Bracy, 1983 (as cited in Riccio, 2004)
Captain's Log	Tarnowski, 1988 (as cited in Riccio, 2004)
Attentional Control Training	McMillan, Robertson, Brock, & Chorlton, 2002
Attention Process Training (APT, APT-2, APT-3)	Sohlberg, & Mateer, 1989, 1993, & 2010

APT-3 is similar to many of the programs described, as it is a computer-based, hierarchically organized training program that aims to restore attentional deficits. Sohlberg and Mateer (2010) designed the program to be similar to their previous models, APT and APT-2, with modifications in administration and categories of attention. A clinician designs the program to be specific to a client's needs, and incorporates plans for generalization. Sohlberg and Mateer (2010) reviewed guidelines published for rehabilitation of cognitive-communication deficits, and used three practice recommendations in the development of their program. First, the program is intended for individuals in the post acute stage of recovery with intact vigilance and mild to moderate impairment of attention, as this group

historically showed better response to treatments. Second, direct attention training will be more successful when it is implemented more than once per week, targeted to individual needs, and used in combination with metacognitive activities. Finally, functional attention goals must be described prior to treatment, and treatment must continually address those goals (Sohlberg et al, 2003). To expand upon the review of literature completed by Sohlberg and Mateer prior to publication of their program, a comprehensive review of the current state of evidence for attention training post TBI was conducted.

Review of Current State of Evidence

In general, the research literature suggests stronger support for the efficacy of attention training over general cognitive training in individuals with traumatic brain injuries (Park & Ingles, 2001; Cicerone et al., 2000; Riccio & French, 2004). Specific trends in the evidence for cognitive rehabilitation of attention after TBI have recently emerged. Based on summative findings from twelve systematic reviews, there is moderate support for direct attention training for patients who:

1) Are in the post acute phase of recovery (Sohlberg et al., 2003; Cicerone et al., 2000, 2005; Riccio & French, 2004; Rohling, Faust, Beverly, & Demakis, 2009)
2) Have experienced a moderate to severe TBI (Snell, Surgenor, Hay-Smith, & Siegert, 2009; Comper, Bisschop, Carnide, & Triccio, 2005; Gordon et al., 2006)
3) Were trained concurrently with meta-cognitive strategies (Sohlberg et al., 2003; Cicerone et al., 2005; MacDonald & Wiseman-Hakes, 2010; Rees et al., 2007)
4) Were trained on complex and functional tasks (Cicerone et al., 2000, 2005; MacDonald & Wiseman-Hakes, 2010)

5) Were trained with stimuli that were presented in a variety of modalities and complexity levels (Cicerone et al., 2000; MacDonald & Wiseman-Hakes, 2010)

Even with adherence to these candidacy issues, treatment effectiveness is task-specific and generalization is not expected unless overtly trained (Cicerone et al., 2000; Coelho et al., 1996). In addition, non-supportive findings were found in 3 of the 12 systematic reviews. Of these, two were specific to individuals with mild TBI, suggesting further research on the effects of attention training or cognitive retraining in this population is warranted (Snell et al., 2009; Comper et al., 2005). The other review with inconclusive findings was conducted on individuals with moderate to severe acquired brain injury, but was not specific to TBI (Rees et al., 2007). The authors reported that drill training and computer-based training were generally ineffective, but showed positive support for increasing speed of processing via dual-task training. Of the 9 systematic reviews that suggested positive support for attention retraining, the following treatment recommendations were made, supplementing the candidacy issues noted above:

1) Individualized treatment sessions (Sohlberg et al., 2003; MacDonald & Wiseman-Hakes, 2010)
2) 1 hour sessions (Sohlberg et al., 2003)
3) Treatment intensity at a frequency of more than once weekly (Sohlberg et al., 2003)
4) Outcome measures that assess functional impacts (Sohlberg et al., 2003; MacDonald & Wiseman-Hakes, 2010).

Also emerging from the reviews were gaps in the current body of literature and attempts to direct future research. The following needs were stated:

1) More detailed specifications for candidacy (Sohlberg et al., 2003; Rohling et al., 2009)
2) Better defined critical features of direct attention training in order to improve efficiency of treatment (Sohlberg et al., 2003; Rohling et al., 2009)
3) Explicit expectations for outcomes of the treatment (Sohlberg et al., 2003; Gordon et al., 2006)
4) Exploration of the most efficacious method to promote generalization (Cicerone et al., 2000, Gordon et al., 2006).

In review of the current practice guidelines, it was noted that the definition of "effective" cognitive retraining is not clearly defined. Some studies report improvements on tasks other than attentional processing as indicative of a lack of control, and therefore inconclusive effects of treatment. Others report a similar generalization of training to other processes as a positive indicator of attention training's impact on memory and executive control. Another source of variability is the population treated. Some of the reviews included people with all acquired brain injuries, while others specified traumatic brain injury.

To further explore the specific trends across individual studies, the author reviewed 30 studies that investigated direct attention training (see Appendix A for a summary). Other attention training programs and general cognitive retraining were also evaluated to obtain a holistic view of the current body of evidence. The following observations were made.

What do randomized control trials tell us about direct attention training?

The highest level of evidence within a research design is a randomized-controlled trial (RCT). Here, six RCTs that evaluated a form of direct attention training serve to determine what the most rigorous studies support. Novack and colleagues (1996) conducted direct attention training on individuals with TBI in the acute period of recovery. They found no differences between their treatment (structured attention remediation) and clinical control (unstructured attention remediation) groups, but did find a significant time effect. That is, both the treatment group and the control group showed significant improvements in cognitive functioning between pre and post measures. This finding suggests that spontaneous recovery is a likely covariate, and exemplifies why APT is not indicated during the acute phase of recovery. An RCT by Gray and colleagues (1992) also found no significant between-group effects. The authors reported significant improvements pre- to post- treatment; however no significant differences were noted between the treatment groups who received micro-computer delivered attention training and the control group which received recreational computing. McMillan and colleagues (2002) implemented Attentional Control Training, a direct attention training program which utilizes traditional cognitive training within a relaxation-like auditory procedure[1], but this treatment found no significant treatment effect in the treatment group, the physical exercise group or the control group. Niemann, Ruff, and Baser (1990) found a significant treatment effect for

[1] In this program, an auditory recording directs one to use relaxation techniques such as intentional breathing as a method to improve sustained attention. This program was developed based on previously established findings that breathing procedures improved focus to a chosen task, and the assumption that that same skill can be learned by individuals with TBI and applied to other facets of attention (McMillan, Robertson, Brock, & Chorlton, 2002).

their treatment group, which received computerized attentional retraining, compared to their control group, which received memory training. However, treatment effects did not generalize to neuropsychological testing. Conversely, the final two RCTs found significant improvements in neuropsychological testing after administration of direct attention training, and also evidenced a significant improvement over that of the control groups (Fasotti et al., 2000; Galbiati, Recla, Pastore, Castelli, & Strazzer, 2009). Interestingly, these studies included hierarchically based training and training of metacognitive strategies (Fasotti et al., 2000; Galbiati et al., 2009), while the RCTs reporting negative findings did not include both. Beyond positive treatment effects, the studies by Fasotti and colleagues (2000) and Galbiati and colleagues (2009) also reported generalization to other measures. Both studies putatively facilitated generalization by training metacognitive strategies. In summary, the RCTs suggest that direct attention training is more successful when hierarchical training is utilized and metacognitive strategies are employed. They also support the notion that candidacy for direct attention training is most ideal during the post-acute stage of recovery.

What do studies with non-supportive findings tell us about direct attention training?

To maintain a non-biased review of the current literature, those studies that reported at least one negative finding were analyzed. Of the 30 studies reviewed, 14 found some degree of non-supportive findings or contraindications for the effectiveness of the attention training. Seven of these studies saw improvements from pre- to post- neuropsychological measures, but not significant differences between treatment groups, and were therefore inconclusive of treatment effects (Gray, Robertson, Pentland, & Anderson, 1992; Park,

Prouxl, & Towers, 1999; Wood & Fussy, 1987; Chen, Thomas, Glueckauf, & Bracy, 1997; Malex, Jones, Rao, & Stubbs, 1984 as cited in Park & Ingles, 2001; Middleton, Lambert, & Seggar, 1991; Piskopos, 1991 as cited in Park & Ingles, 2001). This brings into question the sensitivity of neuropsychological measures as a way to track improvements following attention training. Several studies attributed improvements on neuropsychological measures to learning strategies for taking the tests, rather than improved cognitive processing (Park et al., 1999).

Two other studies showed the opposite pattern, that is, improvement in attentional performance during training tasks (as measured by treatment data), but insignificant generalization to other measures, including neuropsychological and functional measures (Niemann et al., 1990; Gansler & McCaffrey, 1991). Similarly, Sohlberg and colleagues (2000) conducted a study showing significant treatment effects on neuropsychological measures involving executive control, but no carryover to untrained cognitive processes. This was reported as a possibly non-supportive finding; however it could instead speak to the specificity of direct attention training. The previously described non-supportive findings suggest that perhaps some standardized neuropsychological tests may not be sensitive to change in attention processing. In addition, it suggests that direct training of attention may be efficacious, but generalization may be limited or nonexistent, particularly if it was not directly facilitated. The final four studies were conducted on less-than-ideal candidates, namely, those in the acute phase of recovery from TBI (Ponsford & Kinsella, 1988; Novack, Caldwell, Duke, Bergquist, & Gage, 1996; McMillan, Robertson, Brock, &

Chorlton, 2002) and those with mild TBI who received a generic neuropsychological treatment (Cicerone et al., 1996).

What do studies show that specifically examined Attention Process Training?

To explore the efficacy of APT in particular, five studies evaluating this particular treatment program were isolated and summarized. All of the studies reported improvements to some degree (Park et al., 1999; Sohlberg & Mateer, 1987; Palmese & Raskin, 2000; Pero et al., 2006; Sohlberg, McLaughlin, Pavese, Heidrich, & Posner, 2000). Park and colleagues (1999) yielded some negative findings in generalization of attentional cognitive processes, but still concluded that APT is effective in training a specific attentional skill. Overall, these five studies provide substantial support for the improvement of cognitive functioning in the domains targeted through APT. That is, executive functioning, working memory, and attentional control all improved, as suggested by neuropsychological measures, through the training of APT.

Of these studies, Sohlberg and Mateer (1987) were the only researchers to also employ specific training for generalization of attentional processes to daily functioning. Results showed that their participants did experience improvements in functional outcomes as measured by changes in their functional activity status. Pero and colleagues (2006) and Sohlberg and colleagues (2000) also evaluated functional changes, although their studies did not train for this level of improvement. Both observed functional improvements through anecdotal report or changes on the Test of Everyday Attention. These findings are further confirmation that functional generalization is possible when using APT.

Finally, all but one of the five APT studies adhered to the recommendations previously described. Participants were at least one year post onset of their TBI and had a moderate to severe TBI (see Palmese and Raskin, 2000 for an exception). Treatment intensity varied across the studies, but suggested that one to three sessions per week for 10 weeks can lead to improvements in attentional control.

What do we find in studies that assessed activity- or participation-level outcome measures? Studies of direct attention training that assessed activity- or participation-level outcomes were analyzed for trends. Of the 30 studies that evaluated DAT, only 13 reported activity- or participation-level outcomes (Ruff et al., 1994; Ponsford & Kinsella, 1988; Novack et al., 1996; Sohlberg & Mateer, 1987; Wilson & Robertson, 1992; Gansler & McCaffrey, 1991; Cicerone, 2002; Pero et al., 2006; Stablum, Umilka, Mogentale, Carlan, & Guerrini, 2000; Ho & Bennett, 1997; Duval, Coyette, & Seron, 2008; Galbiati et al., 2009; Sohlberg et al., 2000). Improvements beyond the impairment level were observed in 10 out of 13 of these studies. Training of metacognitive strategies or preparation for attentional control in daily life was utilized in 6 of those 10 studies (Sohlberg & Mateer, 1987; Wilson & Robertson, 1992; Cicerone, 2002; Ho & Bennett, 1997; Duval et al., 2008; Galbiati et al., 2009). The remaining 4 studies found generalization to measures of activity- or participation-level functioning *without specifically training for it* (Ruff et al., 1994; Pero et al., 2006; Stablum et al., 2000; Sohlberg et al., 2000). This is counterintuitive to what many reviews of direct attention training suggest. It is generally stated that generalization to daily functioning cannot be expected without intentionally planning for generalization. Findings from these 4 studies

may suggest otherwise, as they reported generalization to rating scales, functional test batteries and activities of daily living (e.g., sustaining attention to a movie) without direct training.

It is most notable that improvements in both neuropsychological testing and functional outcomes (as measured by rating scales, functional batteries, interviews, or observations) were observed in 100% of the studies that utilized metacognitive strategy training or training for attentional allocations in daily life (Sohlberg & Mateer, 1987; Fasotti, Kovacs, Eling, & Brouwer, 2000; Cicerone, 2002; Ho & Bennett, 1997; Duval et al., 2008; Galbiati et al., 2009). These programs all incorporated a form of impairment level neurocognitive training as well. These findings suggest that training for daily strategies to implement allocation of attentional skills may be equally important as training of impairment level attention deficits, and supports the previous conclusion that restorative rehabilitation in combination with compensatory rehabilitation is most efficacious.

Summary of findings and proposal of current study

Recent studies of attention have increasingly shown the positive effects of direct attention training. These positive outcomes are likely due to the awareness of candidacy issues and the incorporation of specific manipulations that facilitate the success of direct attention training. This trend is evidenced by the fact that 7 of 9 studies published since 2000 showed positive support for attention retraining, while only 9 of 21 studies published before 2000 were supportive. Despite the emerging consensus for the general framework of attention training, specific questions remain regarding candidacy issues, outcome

measures, critical features of direct attention training, and the most efficacious methods to promote generalization. Given these questions, and the variability of previous studies, continued research is warranted. The proposed study will examine the efficacy of APT-3 which, to date, has not been experimentally investigated. The study design will be rooted in the findings of the extant research and will evaluate the treatment's effect on functional measures in comparison to impairment level measures. *Specifically, this study will examine the effect of Attention Process Training III at the impairment level (as measured by cognitive and language tests) and participation level (as indicated through a semi-structured interview and questionnaires) in individuals who have sustained a traumatic brain injury.* It is hypothesized that participants will improve in both functional and impairment level measures when treatment follows the guidelines previously described.

METHODS

Participants

Participants were recruited for the study through the assistance of local speech-language pathologists and TBI support group leaders. Three individuals responded to the advertisements. One participant was excluded from the study because he was currently receiving cognitive rehabilitation from an outside facility. The other two participants were included in the study following an initial pre-treatment assessment. The following general criteria were required for inclusion:

a) Mild to moderate TBI
b) At least 1 year post-injury
c) English as primary language
d) Adequate hearing and vision
e) Above 21 years of age
f) No history of psychiatric or neurological disorders prior to onset of injury
d) Intact vigilance
e) Subjective complaints of attentional deficits
f) No active involvement in cognitive rehabilitation programs within the past 6 mo.
g) Available to participate in treatment twice weekly for 8 weeks.

PARTICIPANT 1: TS

TS, a fifty-nine year old male with a bachelors of arts, experienced a mild TBI in a motor vehicle accident 4 years and 9 months prior to the initial testing session. He reported no loss of consciousness or loss of memory surrounding the accident. Immediately following, he received an MRI on his neck which revealed no significant findings. Due to his accident, he retired from his career in construction management. Two years following the accident,

TS obtained a neuropsychological evaluation, as he reported he had never fully recovered from the accident. He subsequently received therapy for organization and relaxation for approximately two months. TS had not received any further cognitive therapy. Upon enrollment in the study, he had been attending a TBI support group for several months. He reported that he was using caffeine to avoid and reduce headaches, but required no other pharmaceutics as a result of his injury. He has a history of sleep apnea that dates to before his injury and is controlled without intervention.

TS reported that his primary concerns following his TBI included "brain fatigue", "multivoice sensitivity", difficulty retaining reading material and learning new material. He described brain fatigue as extreme exhaustion following activities that were previously not taxing. He described "multivoice sensitivity" as his brain attempting to process all audible conversations in a room at once.

PARTICIPANT 2: TT

TT, a fifty-six year old female, experienced a mild TBI in a motor vehicle accident in which she was hit by a semi-truck at highway speeds. Her accident occurred 2 years prior to the initial testing session. She reported that she likely lost consciousness for a minute or two following impact. Since her accident, TT has been on disability leave from her position as a customer service agent with a corporate airline. As a result of this injury, TT required antidepressants to manage anxiety and PTSD.

TT's primary concerns following her injury included difficulty comprehending reading material, requiring several reminders to make an agenda, and difficulty with "daily recall". TT described "daily recall" tasks as tracking dates when making plans, categorizing information, and retaining fast paced information in conversations.

Within the span of 1.5 months, TT completed the pre-testing session and only three treatment sessions. She had two cancellations and four no-shows. Following the fourth no-show, TT was discontinued from treatment. She was in agreement with this decision as she felt it difficult to commit to a consistent treatment schedule.

Study Design

The study used a pre-experimental single-subject A-B-A (i.e. pre-testing, intervention, post-testing) treatment design. The participant received APT-3 treatment during the treatment phase, as outlined by the treatment manual.

Outcome Measures[2]

The following battery of tests was administered to each participant to establish criteria for inclusion, to serve as a baseline measurement, to establish the appropriate cognitive processes to target, and to develop functional goals. The chosen tests allowed for a thorough understanding of the participants' attentional impairments, the impact of those

[2] Although commonly used outcome measures in past studies included the *Paced Auditory Serial Addition Task, Test for Attentional Performance,* and *Vineland Adaptive Behavior Scales*, these tests were unavailable for use in the current study.

impairments on the participants' daily functioning, and their metacognition of their attentional impairments. These measurements were administered in one session prior to the onset of APT-3, and in one session a week following the conclusion of APT-3.

1. *Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)*: The RBANS was used as an overall assessment of the participant's attention and other cognitive functioning. It was chosen for its reliability across multiple administrations. Convergent validity has been established for subtests of the RBANS (Randolph, 1998).
2. *The Test of Everyday Attention (TEA)*: The TEA is a standardized test used to measure activity-level attentional skills through replication of real-life tasks (e.g. searching a telephone book or a map). This test contributed to our understanding of the participant's ability to generalize improvements of attention.
3. *Comprehensive Trail-Making Test (CTMT)*: The CTMT was used as a second neuropsychological measure of the participant's attention.
4. *Brock Adaptive Functioning Questionnaire (BAFQ)*: This 64-item questionnaire asks about a broad range of cognitive issues, including attention and executive functions, to predict executive functioning impairment (Wells, Dywan, & Dumas, 2005). It provided the participant's subjective analysis of the influence of attention training on his daily life. It was also utilized to obtain subjective ratings from a close confidant.
5. *Moss Attention Rating Scale (MARS)*: This scale was given to a close confidant of the participant to obtain subjective ratings of the influence of the participant's attentional skills on his daily activities.
6. *Subjective Interviews*: Interviews were conducted to obtain reports of attentional needs and skills in daily life that were self-identified by the participant.
7. *Sustained Phonation*: As a control measure to exclude spontaneous recovery, measures of sustained phonation were taken each week during the treatment

phase. This measure was selected for its reliance on physiologic endurance rather than cognitive endurance.

Procedures

Treatment procedures followed the program described in the APT-3 manual. Upon completion of baseline testing, individualized treatment programs were designed for each participant. Each treatment plan consisted of specific attention exercises with predetermined starting levels, identification of metacognitive strategies, and designation of generalization activities, explained in detail below. These issues were identified prior to initiation of treatment and adjusted throughout the treatment to provide appropriate support, increase the level of difficulty, and meet the participant's goals.

As described in the APT-3 manual, treatment consisted of three components:

1) *Specific attention exercises*. Exercises to restore attention were selected based on the participant's initial level of functioning across the domains of attention (i.e. basic sustained attention, working memory, selective attention, suppression, and alternating attention). Selective attention, working memory and alternating attention were chosen to target for TS. Tasks within each attentional component were selected to match the participant's initial level of ability. The APT-3 program is hierarchical in nature, and therefore the participant advanced through clinician-selected tasks as mastery was attained (see Appendix B for sample hierarchy tracking spreadsheet). Mastery criteria are not standardized by the program, but rather determined by clinical judgment. Given the participant's performance at the

beginning of the treatment phase, criteria for advancement was set at 90% or greater with a self-rating of difficulty below 9 (out of 10), or a performance of 80% of greater with a self-rating of difficulty below 7. Criteria were set at this level because the participant rarely rated difficulty below 7, despite success. The criterion for returning to a lower level was an accuracy score below 50%. Both criteria were susceptible to slight variations with clinician judgment to maintain a variety of tasks within a given program while maintaining a reasonable level of difficulty for the client. At the conclusion of each treatment session, attention exercises were adjusted to meet the participant's level of functioning, and the participant was given a 45-60 minute home program to complete in the interim prior to the next session.

2) *Metacognitive strategies*. The APT-3 program includes metacognitive strategy training as one of the three components of the treatment program. Metacognitive strategy training is intended to: 1) increase the client's awareness of attention deficits and strengths to facilitate adaptive behaviors; 2) increase the client's motivation (and thus level of effort expended) to participate in attention training; and 3) identify and train specific strategies that are useful for increasing an individual client's attention. At the completion of each attention exercise in the APT-3 program, the participant is asked to evaluate their motivation level during the task and the level of effort required to complete the task. In addition to this exercise, the clinician taught metacognitive strategies to the participant. Strategies were introduced during the second session and adjusted throughout the treatment program (as detailed in Appendix C). During treatment sessions, the participant was

instructed to *PLAN, DO, REVIEW* during each task. He was instructed to plan a strategy, do the exercise, and then review what went well and what may be effective for the next attempt. Initially, the clinician proposed several strategies that may be effective for the participant. Gradually, the participant began to self-select and identify strategies effective for him. The participant was encouraged to utilize these strategies independently during his homework, while targeting functional goals (see below), and during his daily activities.

3) *Functional goals/generalization activities*. Based on the findings of the assessments, the clinician and participant selected the following functional goals that correlated with skills trained in the attention exercises:
   a. Selective Attention: I will be able to ignore background noises better in order to pay attention to the task I want to focus on.
   b. Working Memory: I will be able to read one chapter of a book and feel as though I understood it.
   c. Alternating Attention: I will improve my ability to quickly switch my attention between tasks.

   These goals were selected during the second session, but prior to initiation of the treatment. Functional goals allowed the clinician to encourage carryover of trained strategies to daily activities that require similar attentional control to that trained in treatment sessions. The participant maintained a log of his functional goals documenting progress towards them (see Appendix D). Functional goals were

defined and administered through a modified Goal Attainment Scaling, as defined by the APT-3 manual. Each week the goals were briefly discussed and assessed.

Treatment was administered in the Student Research Lab, twice weekly for 60 minute sessions. Participants in the study were provided with a practice USB drive and were asked to complete exercises 1-2 times outside of the treatment sessions. The treatment period lasted for 7 weeks. During the treatment period, extensive documentation was kept to track the following: therapy dosage, pacing of exercises, strategy training, performance metrics, and decisions about when to modify tasks (see Appendix E for sample spreadsheet). In addition, performance data during tasks and metacognitive evaluations were maintained by the APT-3 computer program.

One week following completion of the training period, the participant completed the same battery of tests that was administered prior to the onset of treatment. See Table 2 and 3 for a schedule of the treatment program and samples of session formats.

Table 2. Treatment Program Schedule

	Baseline Test Battery	Treatment Phase														Post-treatment Test Battery
Session Number	Pre	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Post
	Week 1	Week 2		Week 3		Week 4		Week 5		Week 6		Week 7		Week 8		Week 9

Table 3. Sample of Session Formats

Session 1:

5 min: Review findings from testing session
25 min: Functional goal discussion and selection
15 min: Introduce metacognitive strategies
15 min: Introduce attention exercises
1 min: Sustained phonation duration

Session 5:

45 min: Attention exercises
14 min: Clinician-led metacognitive strategy selection/review (dispersed throughout exercises)
1 min: Sustained phonation duration

Session 10:

10 min: Functional goal check-in
40 min: Attention exercises
10 min: Client-guided discussion of metacognitive strategy use with exercises and functional goals (dispersed throughout exercises)

Data Analysis

Results of the treatment were analyzed in three sections to correspond with the WHO International Classification of Functioning (ICF) levels: test battery findings (impairment

level), treatment data (impairment/activity level), and interview/questionnaire findings (participation level). Data were analyzed and evaluated descriptively to determine the effects of treatment. No statistical analysis was possible due to the inherent lack of probe data available when using the APT-3 program, and the inability to statistically compare standardized test performance of a single subject.

Comparisons of pre- treatment and post-treatment test batteries were conducted using raw scores as well as z-scores. Treatment data were analyzed by ascribing a level to each task/condition combination (see Appendix B for task levels). This process was similar to the approach taken by Zickefoose and colleagues (2013) who published a treatment study on APT-3 and Lumosity while the present study was underway. Within each attentional domain, level of difficulty was defined based on the task difficulty, speed, distracters, prompting, stimuli, complexity, and input type. These factors were all hierarchically listed within the APT-3 program. Tasks with the same attentional demand (e.g. *Listening for one number* and *Listening for one letter in a word*) were assigned the same levels because, purportedly, the level of difficulty remained the same. Session number vs. level of difficulty were graphed and descriptive analysis was utilized to illustrate the trend and slope of the data. An increase in task level indicates that the participant met or exceeded criteria for advancement (i.e. accuracy of 90% or greater with a self-rating of difficulty below 9, or a performance of 80% of greater with a self-rating of difficulty below 7). Corresponding levels across domains of attention do not reflect the same level of task difficulty (e.g., Level 1 within basic sustained attention may not be as difficult as Level 1 in alternating attention).

RESULTS

Pre-Treatment and Post-Treatment Findings (Impairment Level)

Results from pre-treatment and post-treatment standardized measures are shown in Table 4 as both raw scores and standardized z-scores. Scaled and adjusted scores from each measure were converted to z-scores for ease of comparison (z-scores have a mean of 0 and a standard deviation of 1). Changes from pre-treatment to post-treatment are indicated by a positive (+) or negative (-) difference. A positive change typically indicates an improvement in performance on the measure, while a negative change indicates a decline in performance (except where indicated).

Treatment Data (Activity Level)

Information related to task, condition, predictions, strategies, reflections, performance accuracy, motivation rating, effort rating, time, and error pattern were tracked throughout the treatment. Treatment phase performance is displayed in Figures 2 through 7. Treatment data is differentiated from homework data with differing symbols. Where appropriate, a ceiling is shown on the graph, indicating that TS had reached the limit of the attentional domain. See Appendix B for examples of point value determination for each level of difficulty.

Table 4: Raw and converted z-scores on standardized tests pre- and post- APT-3 training.

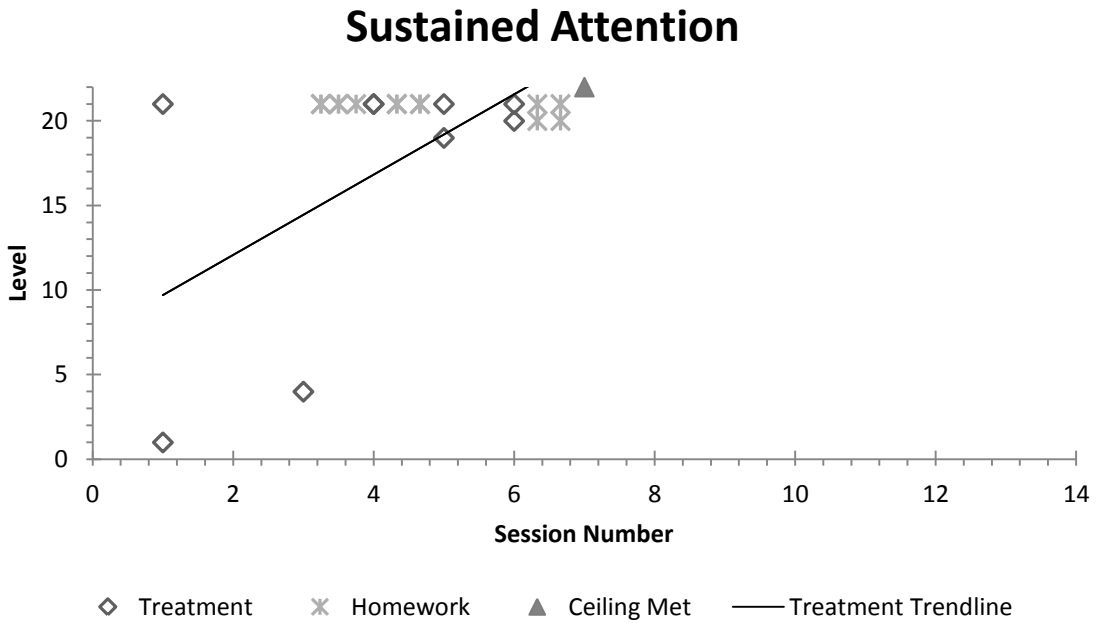
		Raw Scores			*Z-scores (95% Confidence Interval)*		
	Test	Pre-treatment	Post-treatment	Difference	Pre-treatment	Post-treatment	Difference
*RBANS**		*Record Form A*	*Record Form B*		*Record Form A*	*Record Form B*	
Immediate Mem.	List Learning Total	24/40	25/40	+1	-0.40 (-1.07 - 0.27)	-0.20 (-0.87 – 0.47)	+0.20
	Story Memory Total	18/24	17/24	-1			
Visuospatial/ Constructional	Figure Copy Total	20/20	20/20	0	1.40 (0.53 - 2.27)	1.40 (0.53 – 2.27)	0.00
	Line Orientation	19/20	19/20	0			
Language	Picture Naming	10/10	10/10	0	-0.20 (-0.93 - 0.53)	-0.40 (-1.13 – 0.33)	-0.20
	Semantic Fluency	20/40	19/40	-1			
Attention	Digit Span Total	8/16	10/16	+2	-1.00 (-1.73 - -0.27)	-0.60 (-1.33 – 0.33)	+0.40
	Coding Total	43/89	40/89	-3			
Delayed Mem.	List Recall	4/10	4/10	0	-0.07 (-0.87 – 0.73)	-0.93 (-1.73 – -0.13)	-0.86
	List Recognition	20/20	18/20	-2			
	Story Recall	11/12	8/12	-3			
	Figure Recall	13/20	15/20	+2			
Total Scale		---	---	---	-0.13 (-0.60 – 0.33)	-0.27 (-0.73 – 0.20)	-0.14
*CTMT**							
Trail 1		44 sec	33 sec	-11 sec**	-0.40	0.40	+0.80
Trail 2		67 sec	72 sec	+5 sec**	-1.20	-1.30	-0.10
Trail 3		58 sec	47 sec	-11 sec**	-1.00	-0.40	+0.60
Trail 4		34 sec	28 sec	-6 sec**	0.30	0.90	+0.60
Trail 5		61 sec	56 sec	-5 sec**	-0.10	0.20	+0.30
Composite Index		---	---	---	-0.60	-0.10	+0.50
*TEA**		*Version A*	*Version B*		*Version A*	*Version B*	
Map Search I***		41/80	44/80	+3	---	---	---
Map Search II***		69/80	72/80	+3	---	---	---
Elevator Counting		7/7	7/7	0	---	---	---
Elevator Counting w/ Distraction		7/10	8/10	+1	---	---	---
Visual Elevator I		8/10	5/10	-3	---	---	---
Visual Elevator II (Timing Score)		4.71	4.31	-.40**	---	---	---
Elevator Counting w/ Reversal		5/10	7/10	+2	---	---	---
Telephone Search (Timing Score)		3.76	3.53	-.23**	---	---	---
Tele. Search w/ Counting (Dual task decrement)		2.91	2.01	-.90**	---	---	---
Lottery		8/10	9/10	+1	---	---	---

**RBANS = Repeatable Battery for the Assessment of Neuropsychological Status; CTMT = Comprehensive Trail-Making Test; TEA = The Test of Everyday Attention*

***A negative difference indicates an improvement in performance*

****While the maximum score is 80, typical ranges for Map Search I and II are 22-44 and 49-70, respectively*

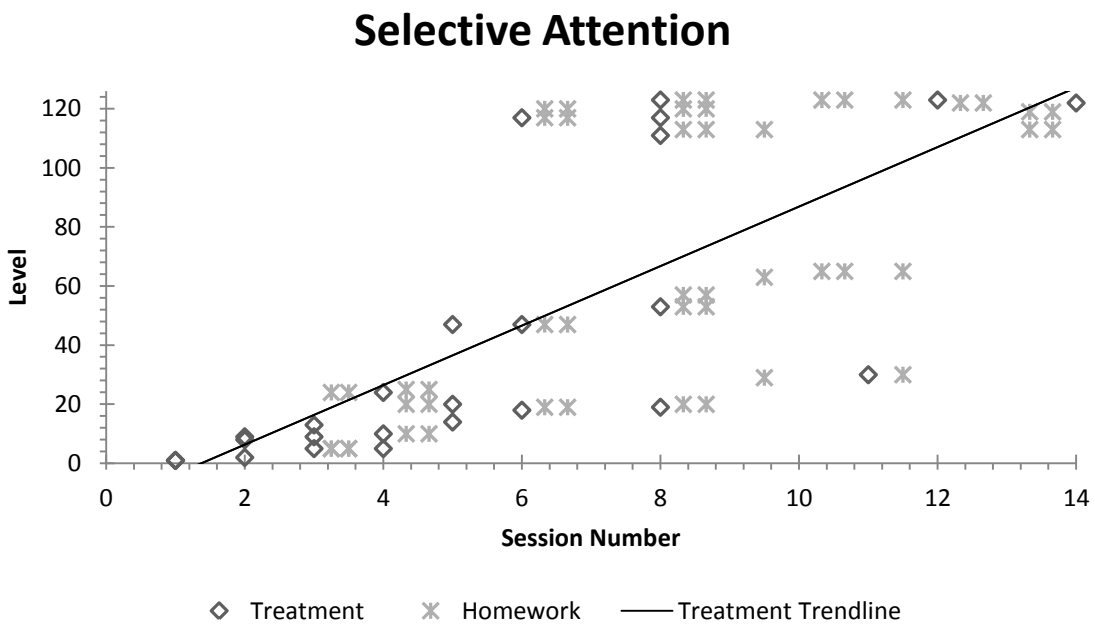
Figure 2. Participant's progression through sustained attention tasks in APT-3 program.



* Trend line (and data points) indicates the rate at which TS met criterion and advanced in level.
** Criteria for changes in level: Criteria for advancement were 90% or greater with a self-rating of difficulty below 9 (out of 10), or a performance of 80% of greater with a self-rating of difficulty below 7. Criterion for reducing level was an accuracy score below 50%.
***Within this domain, TS met the ceiling and sustained attention was no longer targeted.

TS began treatment of sustained attention with basic tasks such as *Listening for 1 Animal Sound* and *Matching Animals (2 back)*. By session 4, he quickly advanced to targeting the second highest task level (Level 21). Sustained attention treatment was discontinued when TS achieved consistent performance above the criteria for advancement, and was able to target the same tasks with distracters in the *selective* attention domain. For example, TS ceilinged out of Level 21 (*Remembering Clock Times [2 back]- slow*) with an accuracy score of 95% and a self-rating of effort of 6. The final level (Level 22- *Remembering Clock Times [2 back]- fast)* was not subsequently targeted as TS was completing a similar version of this task *(Matching Animals [2 back]- slow)* within the selective attention domain.

Figure 3. Participant's progression through selective attention tasks in APT-3 program.

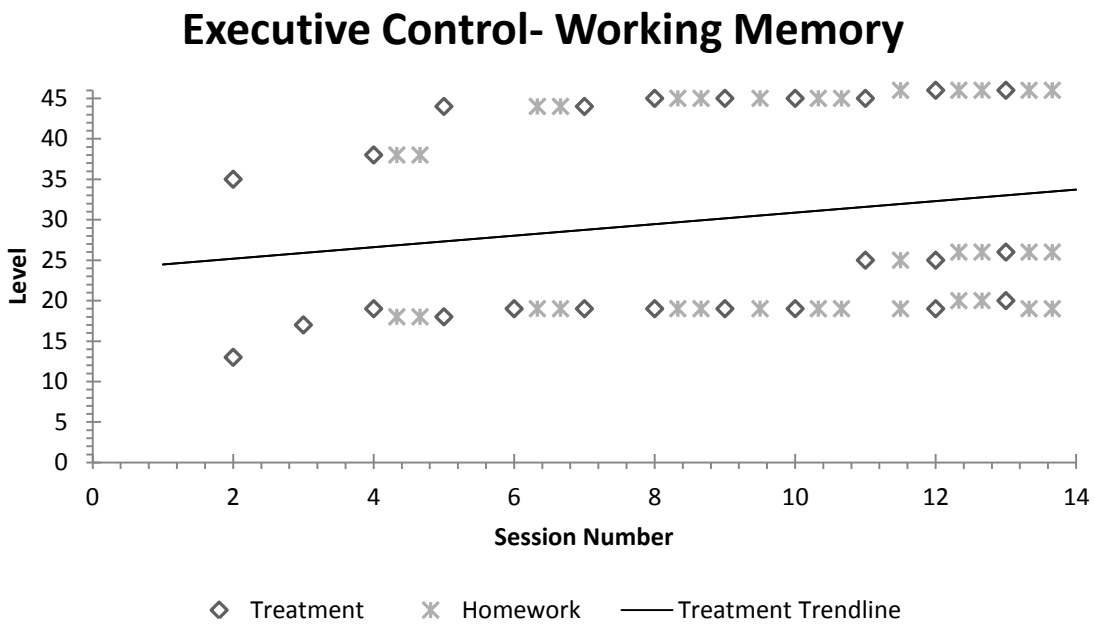


* Trend line (and data points) indicates the rate at which TS met criterion and advanced in level.
** Criteria for changes in level: Criteria for advancement were 90% or greater with a self-rating of difficulty below 9 (out of 10), or a performance of 80% of greater with a self-rating of difficulty below 7. Criterion for reducing level was an accuracy score below 50%.

Training within the selective attention domain began by targeting the lowest level in attempt to identify TS's current level of performance. He advanced through levels until he did not meet criteria on the first try. In this case, treatment targeted that level until TS improved his accuracy score and decreased his self-rated effort score to meet criteria. For example, during session three, a level 5 task was targeted (*Listening for 1 Letter in a Word-slow, with auditory competition*). He received an accuracy score of 87% with an effort score of 10, not meeting the criteria for advancement. This level was again targeted, indicated in Figure 3 by no change in level, until on the fourth session he received an accuracy score of 100% with an effort rating of 5; well within criteria. TS progressed through treatment in this manner for the remainder of the treatment period. In the final session, his performance

on the level he attempted (Level 122: *Matching abstract shapes- 2-back- fast with environmental noise*) was 72% accurate with an effort score of 9. The graph shows several attempts at this level which reflects that he had not met criteria for advancement.

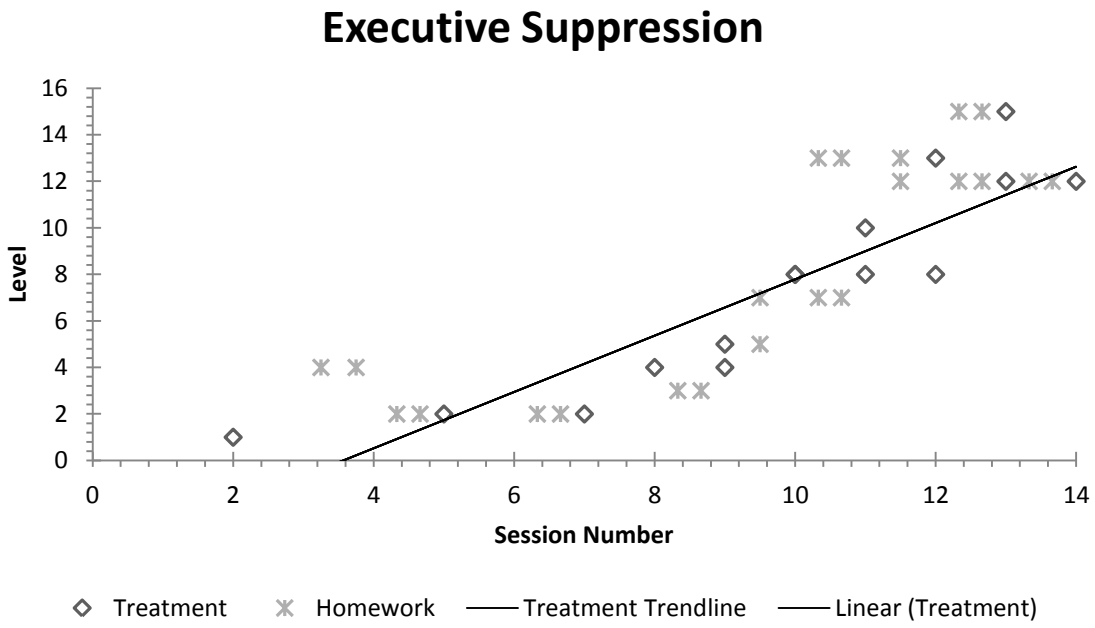
Figure 4. Participant's progression through working memory tasks in APT-3 program.



* Trend line (and data points) indicates the rate at which TS met criterion and advanced in level.
** Criteria for changes in level: Criteria for advancement were 90% or greater with a self-rating of difficulty below 9 (out of 10), or a performance of 80% of greater with a self-rating of difficulty below 7. Criterion for reducing level was an accuracy score below 50%.
*** Two trends are visible in this graph, reflecting progression in two distinct targeted areas.

Figure 4 shows progression through two different targeted areas within the domain of working memory. *Number Sequences (lower cluster of data points)* and *Word Sentences (upper cluster of data points)* both reflect steady but slow progress.

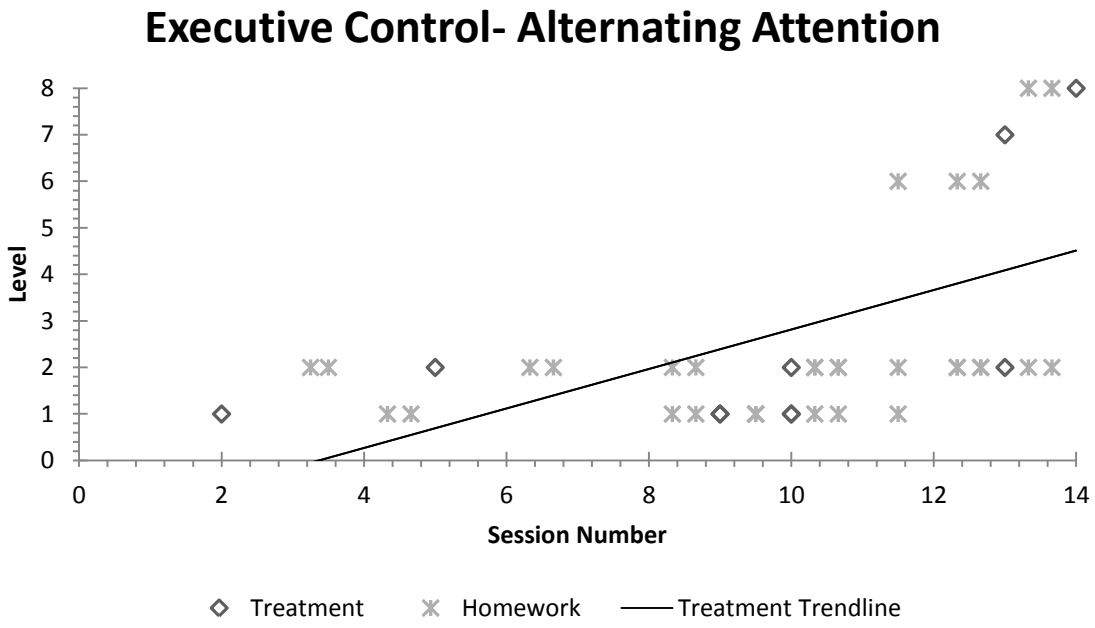
Figure 5. Participant's progression through suppression tasks in APT-3 program.



* Trend line (and data points) indicates the rate at which TS met criterion and advanced in level.
** Criteria for changes in level: Criteria for advancement were 90% or greater with a self-rating of difficulty below 9 (out of 10), or a performance of 80% of greater with a self-rating of difficulty below 7. Criterion for reducing level was an accuracy score below 50%.

Treatment for Executive Suppression began at a Level 1 task (*Above-Below- slow with manual response).* The maximum level that TS reached was Level 15 (*Word Directions- fast with manual response)*. TS progressed quickly through the levels of this task with an initial accuracy score of 73% with effort of 8 on the slow rate. Four days later he scored 92% with an effort of 8 on the same task and was advanced to the final level where he maintained performance at 80-89% with an effort of 10 consistently.

Figure 6. Participant's progression through alternating attention tasks in APT-3 program.

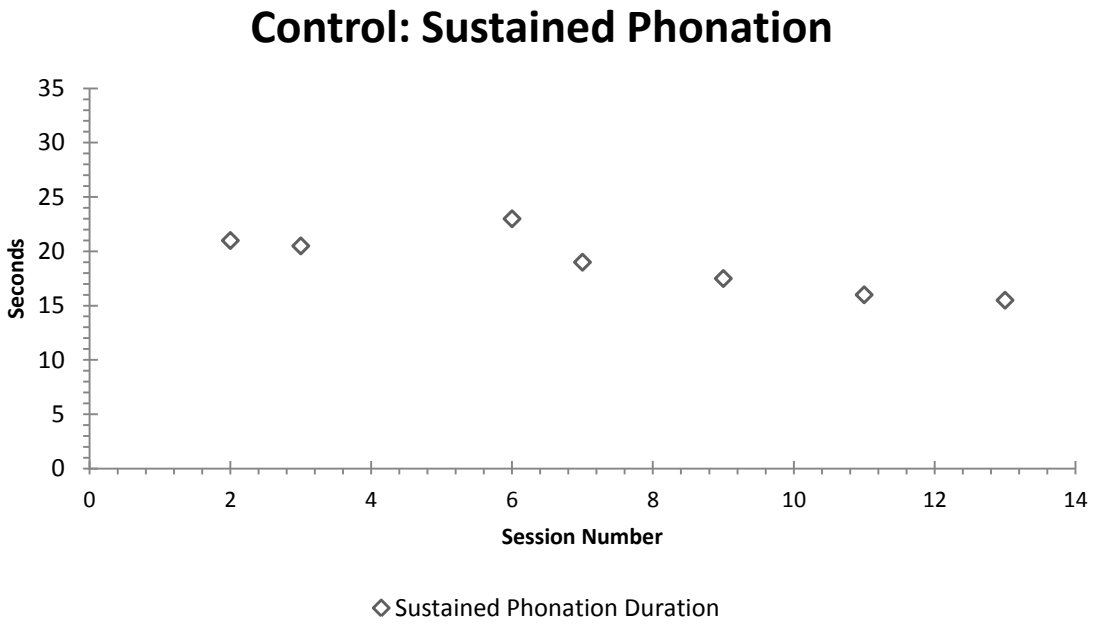


* Trend line (and data points) indicates the rate at which TS met criterion and advanced in level.
** Criteria for changes in level: Criteria for advancement were 90% or greater with a self-rating of difficulty below 9 (out of 10), or a performance of 80% of greater with a self-rating of difficulty below 7. Criterion for reducing level was an accuracy score below 50%.

The trend of the graph in Figure 6 reflects steady increases in level of difficulty. The task targeted in sessions two through nine was *Adult-Child*, which requires the client to manually respond when a voice from a child or an adult matching the word "child" or "adult" is said. After several presentations, the word "switch" indicates that the client should then select when the voice does not match the word. Initially, the task was presented in the slow version, where TS performed with a score of 95% and an effort rating of 8. He was then advanced to the fast version where he received a score of 58% and 45% with efforts of 9 and 10, respectively. Due to the low performance, treatment returned to the previous level for several sessions. TS then advanced again to the fast level, where he

met criteria just prior to the ninth session and advanced to other tasks. This progress continued and during the final three attentional exercise sessions, TS targeted the highest level, Level 8 (*Word Directions- fast)* with scores of 89%, 91%, and 88% and consistent effort ratings of 10.

Figure 7. Participant's sustained phonation duration throughout the APT-3 program.



Weekly measures of the control measure, sustained phonation, ranged from 15.5 seconds to 23 seconds.

Subjective, Anecdotal and Functional Findings (Participation Level)

Questionnaires were administered to assess perceived changes (self and other) over the course of treatment. The Brock Adaptive Functioning Questionnaire (BAFQ) was completed by TS and a close confidant. This confidant also completed the Moss Attention Rating Scale (MARS). Results are shown in Table 5. Both questionnaires are rated using a 5-point Likert

scale. The BAFQ scores are presented as proportions, with a range from .2 (no concern) to 1.0 (maximum concern). MARS results are presented as averaged Likert scaling within each domain with a range from 1 (minimal concern) to 5 (maximum concern)On both measures, a negative (-) difference indicates improvements.

Table 5: Results on Brock Adaptive Functioning Questionnaire and Moss Attention Rating Scale pre- and post- APT-3 treatment.

Test	*Scores* Pre-treatment	Post-treatment	Difference	Pre-treatment	Post-treatment	Difference
BAFQ: Self Rating		*Self Rating*			*Observer Rating*	
Planning	.468	.514	+.046	.543	?	
Initiation	.500	.450	-.050	.400	?	
Flexibility	.600	.550	-.050	.533	?	
Excess Caution	.520	.440	-.080	.550	?	
Attention	.600	.629	+.029	.400	?	
Memory	.550	.525	-.025	.429	?	
Arousal	.560	.440	-.120	.680	?	
Emotionality	.350	.400	+.050	.550	?	
Impulsivity	.314	.229	-.085	.257	?	
Aggression	.200	.200	.000	.240	?	
Social Monitoring	.533	.514	-.019	.371	?	
Empathy	.440	.560	+.120	.480	?	
MARS						
Overall Logit Score				.466	?	
Average Response				2.55/5	?	
Factor I: Restlessness / Distractibility				2.00/5	?	
Factor II: Initiation				3.00/5	?	
Factor III: Consistent / Sustained Attn				4.00/5	?	

? Despite several reminders, the questionnaires were not received from TS's friend.

TS's self rating showed improvements on 5 of the 12 areas assessed by the BAFQ; *initiation, flexibility, excess caution, arousal,* and *impulsivity.* The largest improvement was in arousal, which had been one of TS's primary complaints at the initiation of treatment. Surprisingly, TS rated himself as having more difficulty post-treatment in the areas of planning,

emotionality and empathy. Negligible change (≤ .03) was shown for questions related to memory, aggression, social monitoring and, interestingly, attention.

Subjective findings during treatment were also tracked through comments made by TS during treatment sessions. Comments related to use of strategies outside of treatment, ease of tasks, and functional changes were noted and are described in Table 6. As a whole, TS's comments reflected his keen insight into his deficits. Throughout the treatment he showed increasing ability to think critically to independently identify and utilize strategies for a given task. He identified activities in daily life (e.g. conversations with friends, attending conferences) in which he utilized the strategies targeted in treatment.

Table 6: Participant Report of Concerns and Strategies

	Findings		
	Selective Attention	Working Memory	Alternating Attention
Pre-testing	---	---	----
Session 1	"I don't have a problem when I am at home because I can control my environment" "This should be easy but I used more brain energy than I should"	"I'm not absorbing what I am reading so it isn't enjoyable" "I am focused and not distracted but not absorbing it" "It is harder when the books jump around a lot"	"I usually remove myself from large groups to give myself a break"
Session 2	"I'll use my lip reading strategy. I'll form the descending next number in my mind and quickly get ready for the next"	---	---
Session 3	"The noise really does make it harder"	---	---
Session 4	"I've been forcing myself to look at lips when I listen to people" "I'm going to focus on the mouth of the clinician"	---	---
Session 5	---	"I was more relaxed. I don't have to do it perfectly"	---
Session 6	"Today I'm in a brain fog so I will use more energy"	---	---
Session 7	"I've been having more control over auditory distracters" "I've been using the lip reading technique"	---	---
Session 8	"Labeling helps me hold the information"	---	---
Session 9	"I spent the whole day at Folk Life this week. I wouldn't have been able to do that a few years ago!"	---	"I participated throughout the whole singles group. For my mental break I spoke with a friend in a quieter space rather than going for a walk outside"
Session 10	"I made it through an entire day and a half at a conference. I did use some of my strategies. I took a walk outside during our breaks and a got some water. 3 years ago this would have been impossible. One year ago it would have been eh, ok. "This is really helping me. I would like to see people in my situation get more help sooner. It took me a long time to get the help I needed."	---	"I should have given myself time to adjust to the change of task"
Session 11	---	"I'll use that visual attention in real life"	---
Session 12	"I was at dinner with a group last night. I watched everyone's lips to ignore other conversations." "I should focus on the person's whole face [to focus]" "Maybe I'll relax and go with gut"	"I just need to decide how much brain energy I want to spend [on any given activity]"	"We were at a long table and I did have some trouble with all the conversations that were going on." "I guess I could group the conversation to keep track better"
Session 13	---	---	---
Session 14	---	---	(In discussing what he will do after treatment) "I could do luminosity or Sudoku. I have a lot of information."
Post-testing	---	---	---

A final measure of functional change was obtained through pre- and post- treatment interviews. Findings are summarized in Table 7. The most pronounced changes noted by TS following treatment were returning to working 6 hours a day several days a week, a decreased emphasis on needing naps, and fewer forgetful moments.

Table 7: Pre- and post- treatment interview findings

	Pre-Treatment	Post-Treatment
"How do you typically spend your day?"	-**Sleep about 10 hours, plus naps**	-**Sleep about 10 hours; few if any naps**
	-Morning is most functional, errands and projects (such as yard work, working on vehicles), showers, etc	-Journal, reads a chapter in his Bible, prays, eats breakfast -Work on a bigger project
		-Works for brother about 6 hours a day (9:00-3:00). Doing clean-up, demo, repairs
	-Afternoon/evening goes to church/fellowship	
	-Walking a lot, goes to YMCA regularly	-A lot of time spent prayer walking
	-**Frequently has "oh well" moments, ~10x per week:** leaving keys in trunk, forgetting things at home, driving past exit, forgets where car is parked.	**-Occasionally experiences some "oh well" moments:** sometimes forgets to bring a key somewhere
"Do you feel that you are having trouble with your attention?"	**-Prior to injury, read 3-4 chapters in a sitting (about 30-40 minutes). Now reading 1 chapter and "doesn't get as much out of it"** -Reads words but has more trouble processing information	-**Now reading a little more, but "still a significant change"**
	-**Barriers to getting back to work are needing a mid-day nap and frequent headaches**	**-Barriers now include occasional headaches and requiring shortened work days; however, no longer requires a daily mid-day nap. "I'm glad I can work some, but still contractors aren't interested in someone who can work 6 hours"**
	-"Movies are enjoyable, but if I see it a second time it's like a whole new movie, which wasn't always the case"	-Movies are still occasionally overwhelming. Recent movie "flooded him with sensory input" and he decided to leave.
	-Tries to process all conversations in a room, so he prefers 1:1 conversations in a quiet room	-**In groups and noisy environments he has implemented strategies to attend to desired stimuli**
	-**Has tried to eliminate multitasking from life**	-**Systematically reintroducing multitasking into daily life**
		-"I haven't been doing brain exercises like I wanted to because I've been busy. I've worked for my brother several times."
"On a scale of 1-10, how confident are you that you can achieve what you set out to do each day?"	**8: Modifying day to what he can achieve**	**8: "I'm at a point where I put reasonable expectations. So almost always I do my limited to-do lists. I make a list on a 3x5 card."**

DISCUSSION

Results of this study support the hypothesis that individuals with TBI may improve in functional and impairment level measures following direct attention training. Specifically, APT-3, which implements the combined approach of attention exercises, metacognitive strategy training and generalization activities, can be effective in remediating attention deficits following TBI. Overall, finding of this study are consistent with the trend toward positive outcomes in the direct attention training literature.

Challenges prior to treatment

TS's areas of weakness were determined prior to treatment through formal testing and his subjective report of deficits. The *Repeatable Battery for the Assessment of Neuropsychological Status* identified attention as TS's primary challenge, with a z-score of -1.0 (0.60 below any other cognitive domain). Other areas of relative weakness were Trails 2 and 3 on the *Comprehensive Trail Making Test* (CTMT), and Elevator Counting with Distraction and Telephone Search with Counting (Dual task decrement) on the *Test of Everyday Attention* (TEA). Trails 2 and 3 both tax a selective component of attention. The subtests with the weakest scores on the TEA suggest deficits in auditory-verbal working memory and auditory selective attention (Robertson, Ward, Ridgeway, & Nimmo-Smith, 1994). Using questionnaires, TS self-identified attention and flexibility as areas of deficit. TS's confidant identified arousal as the primary area of deficit according to the BAFQ and consistent/sustained attention as the primary areas of concern on the MARS.

TS also conveyed via interview and weekly conversations his primary concerns with daily functioning after his TBI. He identified an increase in fatigue resulting in a need to sleep 10 hours a night in addition to afternoon naps. He also identified his inability to return to work due to "brain fatigue". "Multivoice sensitivity" and difficulty retaining information from readings were also complaints. Through further discussion, difficulty with reading was attributed to deficits in holding and manipulating information read, rather than filtering out extraneous distracters. "Multivoice sensitivity" was described as an inability to select a conversation or stimulus to attend to when multiple auditory inputs were present.

Theory-driven treatment

The subjective complaints of TS, coupled with the findings from formal testing, were mapped onto Sohlberg and Mateer's clinical model of attention in APT-3 (2010). Selective attention, executive control of working memory and executive control of alternating attention were selected as treatment targets. Other domains within this clinical model included basic sustained attention and executive suppression. Basic sustained attention was a strength of TS's, as evidenced by the assessments and his rapid progress through treatment tasks. He met the ceiling for basic sustained attention tasks within five sessions. Executive control of suppression was also a strength of TS's. He was able to steadily advance through the task levels as evidenced by the slope in Figure 5. TS consistently achieved accuracy ratings at or above 90%. This domain was used in treatment for TS to maintain strong levels of suppression and to enhance self-awareness of this process.

Conversely, TS's biggest challenges were in selective attention, executive working memory, and executive alternating attention. During treatment, functional goals, attentional exercises, and implementation of metacognitive strategies primarily targeted these three domains. As described by Sohlberg and Mateer's (2010) model of attention, working memory and alternating attention require a more advanced skill, i.e., executive control of attention, than the process of selective attention. Thus, selective attention was targeted more heavily prior to intensive treatment of working memory and alternating attention. TS responded well to strategies to improve selective attention, and showed a positive trend in treatment data (Figure 3). The slope of the trend line suggests steady and relatively rapid change in task difficulty level. In comparison, the trend lines representing treatment progress for working memory and alternating attention both show a positive but gradually changing trend, with more modest slopes. This pattern suggests a slower rate of improvement and is consistent with the relatively greater cognitive challenge posed by these processes (Sohlberg & Mateer, 2010).

Beyond treatment data, progress in the domain of selective attention was also seen in formal measures. For the TEA, all four subtests measuring selective attention showed improvements (Map Search I & II, Telephone Search- Timing Score, & Elevator Counting with Distraction), strengthening the assertion that APT-3 was helpful in mitigating TS's selection attention deficit. The modest improvement in treatment data for alternating attention and working memory was bolstered by the improvements in formal testing in these areas. For the TEA, two of the three subtests assessing alternating attention showed improvements. That is, Telephone Search with Counting (Dual Task Decrement) as well as

Visual Elevator II (Timing Score) both showed gains from pre- to post- treatment, while Visual Elevator I showed a decrease in performance. Both of the TEA subtests assessing working memory showed improvements (Elevator Counting with Distraction & Elevator Counting with Reversal). Thus, despite the added challenge of executive control of attention (Sohlberg & Mateer, 2010), the modest treatment gains in the domains of alternative attention and working memory appeared to translate into notable gains in a comprehensive standardized measure of attention such as the TEA.

Improvements in the targeted domains of attention were also observed in subtests of the *Comprehensive Trail-Making Test*. As a whole, TS completed the five subtests of the CTMT 28 seconds faster following APT-3 treatment. Specifically, he improved in efficiency on one of the two trails assessing selective attention (Trail 3, but not 2) which are measured by TS rapidly connecting a series of numbers in a specified order as fast as possible. Further, TS improved on both of the subtests assessing working memory/alternating attention (Trails 4 & 5). Trails 4 and 5 are an indicator of executive control of attention, specifically working memory and secondarily alternating attention (Sanchez-Cubillo et al., 2009; Arbuthnott & Frank, 2000), and were measured by TS rapidly connecting a series of numbers and letters as quickly as possible. Thus, TS's overall performance on the CTMT and TEA, together with treatment data, suggests attention improved across the WHO model levels of impairment and activity limitations.

Comparable improvements were seen at the level of participation restriction. Subjective findings through comments during treatment suggest the most improvement with selective

attention, followed by executive control of alternating attention, and finally executive control of working memory. For both selective and alternating attention, TS mentioned strategies he was using in daily life. For example, he stated "I was at dinner with a group last night. I watched everyone's lips to ignore other conversations." He mentioned strategies to manage alternating attention by stating, "we were at a long table and I did have trouble keeping up with [both] the conversation that were both on… I guess I could group the conversations to keep track." He also independently gave examples of activities he had been able to participate in that he was previously unable to do (e.g. "I spent the whole day at Folk Life! I wouldn't have been able to do that a few years ago!"). Subjective improvements were also identified through the pre- and post- treatment interviews. The most significant changes included a change in work status, an overall decrease in fatigue, and a decrease in forgetful moments. Impressively, TS had begun working for his brother for 6 hours a day which he was unable to do prior to treatment. His emphasis on the need for extensive sleeping and naps decreased during his post- treatment recount of daily acitivities. Finally, TS mentioned that although he is still experiencing some "oh well moments" (e.g. forgetting keys), they are occurring less often. These primary areas are not directly associated with a specific attentional component, but likely reflect reduced fatigue associated with increased cognitive efficiency.

Direct attention training and cognitive rehabilitation

The findings from this study suggest improvements for the domains of attention that were trained, specifically selective attention, and executive control of alternating attention and working memory. TS was able to employ effective strategies for use with each domain (e.g

selective vs. alternating attention). These results align with the clinically based model of attention which differentiates sustained, selective, working memory, suppression, and alternating attention (Sohlberg & Mateer, 2010).

This study provides support for a combined compensatory-restorative model of cognitive rehabilitation. APT-3 inherently combines the two treatment models into one cohesive program. Specifically, the decontextualized direct attention exercises aim to restore attention networks, while the functional daily tasks and metacognitive strategies aim to provide compensatory strategies in daily tasks. At present, the cognitive rehabilitation literature has established that a combined approach to rehabilitation is optimal (Gordon et al., 2006; Rees et al., 2007; Roberston & Murre, 1999, Coelho et al., 1996). However, it is still difficult to disentangle the benefit of attention exercises versus meta-cognitive strategies. This continues to be an area that warrants further research (Sohlberg et al., 2003, Rohling et al., 2009). Interestingly, a recently published study by Zickefoose and colleagues (2013), which showed significant treatment improvements but limited generalization, reported no metacognitive strategy training or functional attentional goals. The present study supports established evidence that a combination of restorative rehabilitation with compensatory rehabilitation is important for effecting change across impairment, activity, and participation levels (Sohlberg & Mateer, 1987; Fasotti, Kovacs, Eling, & Brouwer, 2000; Cicerone, 2002; Ho & Bennett, 1997; Duval et al., 2008; Galbiati et al., 2009).

The present study also was compared to the six studies that specifically evaluated *Attention Process Training*. Three of these studies (Park et al., 1999; Palmese & Raskin, 2000;

Zickefoose et al., 2013) reported questionable or null effects of APT training. None of these studies reported specific training of metacognitive strategies or generalization activities. In the largest of the studies to date, Park and colleagues (1999) used the early version of APT to train 23 participants with severe TBI, and compared their performance on the *Paced Auditory Serial Additional Task* and the *Consonant Trigrams Test* to an age-and education-matched control group. The authors reported that the treatment group did not differ in performance compared to the control group (who only received the outcome measures, not the treatment). Unfortunately, this comparison is of questionable validity as the control group data was gleaned from a separate study, with a completely different protocol, conducted a decade earlier. Of the three studies that reported positive outcomes of APT (Pero et al., 2006; Sohlberg & Mateer, 1987; Sohlberg et al., 2000), the majority of the participants had severe TBIs. While only one of the studies explicitly mentioned training for everyday generalization (Sohlberg & Mateer, 1987), all three studies attempted to measure functional outcomes.

As discussed previously, a summary of systematic reviews on DAT identified five candidacy recommendations and four treatment recommendations:

Candidacy recommendations

1) Are in the post acute phase of recovery (Sohlberg et al., 2003; Cicerone et al., 2000, 2005; Riccio & French, 2004; Rohling, Faust, Beverly, & Demakis, 2009)
2) Have experienced a moderate to severe TBI (Snell, Surgenor, Hay-Smith, & Siegert, 2009; Comper, Bisschop, Carnide, & Triccio, 2005; Gordon et al., 2006)
3) Were trained concurrently with meta-cognitive strategies (Sohlberg et al., 2003; Cicerone et al., 2005; MacDonald & Wiseman-Hakes, 2010; Rees et al., 2007)

4) Were trained on complex and functional tasks (Cicerone et al., 2000, 2005; MacDonald & Wiseman-Hakes, 2010)
5) Were trained with stimuli that were presented in a variety of modalities and complexity levels (Cicerone et al., 2000; MacDonald & Wiseman-Hakes, 2010)

Treatment recommendations

1) Individualized treatment sessions (Sohlberg et al., 2003; MacDonald & Wiseman-Hakes, 2010)
2) 1 hour sessions (Sohlberg et al., 2003)
3) Treatment intensity at a frequency of more than once weekly (Sohlberg et al., 2003)
4) Outcome measures that assess functional impacts (Sohlberg et al., 2003; MacDonald & Wiseman-Hakes, 2010).

With the exception of one of the candidacy recommendations (severity of TBI), TS and the treatment program met all of the above recommendations. TS experienced a mild TBI resulting in moderate deficits in attention; however, the candidacy recommendations described TBI with a severity of moderate to severe as the ideal candidate. This study thus provides support for these recommendations and begins to extend the recommendations to individuals with mild TBI. TS did meet specific candidacy criteria defined by Sohlberg and Mateer (2013) which recommended APT-3 for use with individuals who have experienced mild to moderate impairment in attention.

In summary, findings from this study indicate positive treatment effects (as measured by attention-specific impairment measures, activity level measures, and participation measures) for APT-3 in an individual with mild TBI when the practice recommendations below, stated by Sohlberg and Mateer (2013), are implemented.

1) Post-acute recovery with intact vigilance and mild to moderate impairment of attention
2) Treatment implemented more than once per week, individualized and includes implementation of metacognitive strategies
3) Functional attention goals described prior to treatment with treatment intentionally addressing

Limitations and Future Directions

There are several limitations to the current study. First, the small sample size of a single case study does not allow for statistical analysis of pre-post measures. Statistical results would enable a more potent contribution to a larger body of cognitive rehabilitation literature. Another limitation to this study was the inability to control for effects of attentional exercises versus metacognitive strategies. An improvement that may benefit the usability of the APT-3 program would be to include a probe measure within each domain of attention. This would allow a means for measurement of progress through the treatment program. Treatment data is susceptible to treatment effect; therefore, a probe measure within each domain may be effective for clinicians to determine progress and establish measurable activity-level treatment goals as well as determine effect size of treatment. A question posed by the extant literature was to define the key components of cognitive therapy. This study was unable to distinguish effects of treatment due to attentional exercises from those from metacognitive training. Given the findings, it can be assumed that a combined approach is effective; however, future research should attempt to ascertain effectiveness of those factors separately.

A consideration for future studies is to determine the effectiveness of follow-up treatment periods in cognitive treatment. An effective frequency of initial treatment has been determined to be two or more sessions weekly for six to ten weeks; however, there is no mention in the literature as to the effects of additional treatment in the chronic phase of the cognitive challenges. It is possible that an individual may be prepared to make further gains following a year of implementing strategies and skills gained from the initial treatment period.

Limitations of the treatment program included several technical flaws that if addressed, will improve the efficiency and ease of use of the APT-3 program. TS complained of introductory phrases being distracting during working memory tasks. For example, the narrator would intermittently make statements such as “Are you ready?” before stating a sentence to be arranged alphabetically. This distracted from TS’s ability to prepare for the sentence, as the comments were interjected seemingly randomly. There were also several occasions where the presentation of stimuli cut-off part way through phrases. This most often occurred during strings of numbers presented during working memory tasks. On occasion, TS reported a metronome-like sound that remained throughout his home practice program. A heartbeat noise during the effort/motivation selection screen was also reported to be distracting by TS. Future software improvements may also include saving an indefinite amount of treatment data, as currently only the most recent six attempts within each task are saved.

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Appendix A

Summary of studies investigating Direct Attention Training

Author(s)	Study Design	Number of Subjects	Participant Demographic	Treatment Conditions	Outcome Measures Utilized	Conclusions Regarding Impairment Level Impairments	Conclusions Regarding Activity/Participation Level Impairments
Galbiati, Recla, Pastore, Castelli, & Strazzer, 2009	Class I: Randomized, controlled, group design	65	TBI; Age 6-18 years	Remediation training for attention: Combined process-specific treatment and metacognitive strategy training	Wechsler Intelligence Scale, Continuous Performance Test II, Vineland Adaptive Behavior Scales	Significant differences between the two groups on CPT-II and VABS	"Adaptive skills" were affected positively
Duval, Coyette, & Seron, 2008	Class III: Single case	1	Memory deficits s/p operation for cerebral tumor	Cognitive rehabilitation (graduated exercises) and ecological rehabilitation (functional exercises); Based in Baddeley's model of attention, central executive component of working memory (model of attention); Employs strategy training to specifically activate all components of the CE	Neuropsychological evaluation; Ecological questionnaires	Positive effects observed in all areas of working memory	Positive effects observed
Pero, Incoccia, Caracciolo, Zoccolotti, & Formisano, 2006	Class III: Case Study	2	Severe TBI; Chronic phase; Ages 15-35 years	APT Training length depended on progression: 85 sessions, 75 sessions	TAP, TEA	Both patients showed some degree of recovery, specifically in tasks requiring selective vigilance. Differences in what areas of attention each participant improved on, which shows importance of considering their attentional capabilities thoroughly in order to plan treatment and prognosis. APT training was ineffective in modifying the patient's response speed	Functional battery also showed improvements, Functional scales reflected generalization to functional activities.

Cicerone, 2002	Class II: Non-randomized, case-comparison, prospective, group design	8	Mild TBI; Average months p/o = 8.25; Control group met same criteria but were unable to participate in treatment (geographical distance, etc)	Treatment: Working memory tasks (n-back task, n-back with intermittent verbal generation, n-back with continuous secondary task) combined with metacognitive strategy training; Control: No treatment 60 min/week for 11-27 weeks	Trailmaking, PASAT, Continuous Performance Test of Attention, Test for Automatic Detection Speed and Controlled Processing Speed, Attention Rating and Monitoring Scale, and informal reports of changes in status for vocational roles	Treatment group exhibited significantly greater change on standard measures, demonstrating clinically meaningful improvement in 58.3% of the measures, while the comparison group demonstrated clinically meaningful improvements on 12.5% of the measures; Primary effect on attention with no effect on processing speed.	All experimental participants resumed vocation or social roles; Treatment group had greater reduction in self-reported experience of attention difficulties
McMillan, Robertson, Brock, & Chorlton, 2002	Class I: Randomized, group design	145	Varied severity of TBI; 3-12 months p/o	Treatment group: Attentional Control Training Physical tx group: Physical exercise Control: No treatment 5 sessions, 45-min each	TEA, Adult Mem & Info Processing Battery, PASAT, TMT, Sunderland Mem Questionnaire, Cognitive Failures Questionnaire, Hospital Depression and Anxiety Questionnaire, General Health Questionnaire, Rivermead Post-Concussional Symptoms Questionnaire	No significant improvements in any of the groups were noted. The treatment group and the physical treatment group did note improvements on the Cognitive Failures Questionnaire, but not significantly so.	No improvements noted in any group
Fasotti, Kovacs, Eling, & Brouwer, 2000	Class I: Randomized, group design	22	Severe TBI	Treatment: Time Pressure Management with metacognitive strategy training; Control: Generic concentration training	PASAT, ACT, Choice Reaction Time Task, Wechsler Adult Intelligence Scale	Participants receiving TPM showed significantly greater use of self-management strategies; Both groups improved task performance significantly on an information intake task. TPM appeared to generalize to other measures of speed and memory functioning	---
Palmese & Raskin, 2000	Class II: Single case study, multiple baseline A-B design	3	Mild TBI; minimum 1 year p/o	Treatment: APT-2; Control: Educational and application programs 1 hour per week; 10 weeks treatment and 6-7 control	Consonant Trigrams, PASAT, SDMT, Stroop, TORS, DV, R-APT	Following the treatment phase attention and performance speed improved in each of the individuals and remained stable in the absence of treatment for at least 6 weeks. All showed some degree of improvement after the treatment tasks, and some degree of improvement after control tasks, which indicates effects of APT to be relatively stable, and that effects may not be specific to the APT-2 program.	---

Stablum, Umilka, Mogentale, Carlan, & Guerrini, 2000	Class II: Non-randomized, controlled, quasi-experimental	20	CHI; Adults	Computerized dual-task	Dual-task assessment, PASAT	Carry-over effects observed and performance improved with training of a dual-task of executive function	Anecdotal reports of impact on daily activities (e.g. able to watch an entire movie)
Sohlberg, McLaughlin, Pavese, Heidrich, & Posner, 2000	Class II: Randomized, group, crossover design	14	Mild-Severe TBI; Ages 18-60 years; 1-5 years p/o	Treatment: APT; Control: Education 3 hours per week for 10 weeks; additionally 1 hour per week for education	Trail Making Test, PASAT, Gordon Diagnostic, COWAT, Covert Orienting, Continuous Performance Task, Stroop Task, Sternberg Task, BAFQ, DEX, Attention Questionnaire	APT improved performance on tasks involving executive functioning. Minimal effect on vigilance or orienting. No carry-over to other cognitive processes was observed. Education improved self-reports of psychosocial functioning	Functional examples of memory and/or attention improvements noted in surveys and interviews
Park, Prouxl, & Towers, 1999	Class II	23	Severe TBI; 1-4 years p/o	APT; Matched to a control group from a previous study Twenty 120 minute sessions over 7 months	PASAT, Consonant Trigrams, Beck Depression Inventory	Significant pre- to post-treatment effect. Training group improved more, but not significantly so, on the PASAT. Improvements observed on Consonant Trigrams in treatment group only. No effect on Beck Depression Inventory.	---
Chen, Thomas, Glueckauf, & Bracy, 1997	Class II: Ron-randomized, controlled, group design	40	TBI	Treatment: Direct retraining of attention through computer-assisted cognitive rehabilitation (CACR); Control: No treatment	---	No significant differences between groups	---
Ho & Bennett, 1997	Class III: Retrospective single group, pre-test post-test design	36	Mild-Moderate TBI	Neuropsychological training combining remediation and compensatory strategies	Neuropsychological test battery	Significant differences found on all neuropsych test scores, but discussion suggests neuropsych tests may be insensitive to changes	Significant improvements in functional performance (i.e. ADLs)

Novack, Caldwell, Duke, Bergquist, & Gage, 1996	Class I; Randomized, controlled, group design	44	Severe TBI; Acute	Treatment: "Focused" computerized activities (i.e. hierarchical stimulation program); Control: "Unstructured" computerized activities (i.e. non-sequential, nonhierarchical intervention) Averaged 20 sessions, 30 min, 5x per week	Digit span forward/backward/total, Wechsler Memory Scale, Simple and Choice Reaction time, Functional Index Measure (ADLs), Logical Memory, Sentence Repetition, Judgment of Line Orientation, Trail Making Test, Arithmetic Subtest of Wide Range Achievement Test, Visual Imperception	No significant differences between the groups regarding skills or cognition or function. Overall there was a significant effect of time with all subjects performing significantly better at discharge	No significant differences
Cicerone et al., 1996	Class III: Non-randomized, retrospective, group design	20	Mild TBI; Mean age of 34.8, 38.8	Evaluated a neuropsychological program's effect on neuropsychological measures; Grouped based on level of outcome measures	---	The group with good outcomes improved on 46% of measures, group with worse outcomes 7% of the measures; 50% improvements pre-post; Shows variability in recovery s/p mTBI	---
Ruff et al., 1994	Class II: Randomized, multiple baseline, group design	15	Severe TBI	THINKable 20 hours in total	Computer task performance, Psychometric measures, Patient and observer ratings of everyday attention and memory behaviors	Improvements in 2/7 of the measure, and only minimal changes in the other 5. Significant improvements on computer tasks and psychometric measures.	Significant improvements on patient and observer psychometric ratings
Gray, Robertson, Pentland, & Anderson, 1992	Class I: Randomized, controlled, group design	31	Mild-Moderate TBI or Vascular Injury; 7 weeks-10 years p/o	Treatment: Computerized attention retraining; Control: Recreational computer use 14 sessions of 75 minutes each, over 3-9 weeks	Neuropsychological test battery consisting of 22 tests	At initial follow up there was no significant difference between the two groups. At the 6-month follow up the treatment group performed significantly higher. Suggests that the control group initially displayed benefit from attention on computer, but treatment group continued to receive benefits post treatment	---

Wilson & Robertson, 1992 as cited in Cicerone et al., 2000	Class III-Single case study	1	Severe TBI; 9-13 months p/o	Systematic attention training while reading with simultaneous strategy training 4 trials per day for 40 days	Duration without attentional slips; Number of slips	Statistically significant decrease in the number of attentional slips while reading	---
Middleton, Lambert, & Seggar, 1991	Class II: Non-randomized, non-controlled, group design	---	TBI	Treatment: Micro-computer assisted direct retraining of attention and memory; Control: Training reasoning and logical thinking 8 weeks of treatment	Three measures of attention and memory, and three measures of reasoning and logical thinking	No significant differences between the two treatment groups; Both groups improved in 5/6 of the measures	---
Piskopos, 1991 as cited in Park & Ingles, 2001	---	---	---	Direct retraining of attention	---	No significant improvements	---
Gansler & McCaffrey, 1991	Class III: ABA, single-subject design	4	TBI	Hierarchically ordered attention program based on Posner's four component model 4 weeks	Attention measures, Self report of Activities of daily living	No clinically significant improvements in attention, neuropscyh, psychological characteristics, activities of daily living or subjective ratings; Only 1 patient out of 4 demonstrated increases in attentional capacity	Subjects ratings of performance of ADL's increased, but that of their significant others didn't show improvements
Niemann, Ruff, & Baser, 1990	Class I: Randomized, controlled, group design Controlled	26	Moderate-Severe TBI; 12-72 months p/o; Age 6-60 years	Treatment: Computerized direct retraining of attention; Control: Comparison treatment consisting of memory training 2 hour sessions twice weekly for 9 weeks	Trail Making Test, Test d2, PASAT, Divided Attention Test, Rey Aud Verbal Learning Test, Learning Block Span Test, Ruff Test, Logical Memory subtest of the Wechsler Memory Scale	Treatment group improved more on all four measures of attention, but did not generalize to other neuropsychological testing	---

Gray & Robertson, 1989	Class III: Experimental case studies	3	Severe TBI	Micro-computer based attention training	---	Produced change in targeted function and measured attention increase	---
Ponsford & Kinsella, 1988	Class II: Non-randomized, control, multiple baseline across subject, group design	26	Severe CHI; Acute; 17-38 weeks p/o	Treatment: Directed computer tasks; Control: Independent computer tasks 30 min for 15 days w/o fdbk, 30 min 15 days w/ rf	Four-choice Reaction Time Task, Symbol Digit Modalities Test, Two-letter Cancellation Task, WAIS/NHAIS Similarities Subtest, Rating Scale of Attentional Behaviors	No significant treatment effect observed. Some trends observed in single-subject performance level. Spontaneous recovery or practice effect cannot be ruled out	No significant change on rating scales
Ben-Yishay, Piasetsky, & Rattock, 1987 as cited in Coelho, DeRuyter, & Stein, 1996	---	11	TBI	Orientation Remedial Module; Five tasks involving reception of visual and/or auditory stimuli and elicitation of simple visuomotor responses	---	Subjects progressed from impaired to normal range for all five tasks after training and at 6-month follow-up	---
Strache, 1987	Class II; Controlled group design	45	TBI, Vascular injury; 6 mo - 3 years p/o;	Experimental Treatments: Standardized attention training; Progress dependent attention training; Control Treatment: General rehabilitation 20, 30 minute treatment sessions over 4 weeks	Attention measures, Memory measures, and Intelligence measures (non specified)	Both experimental treatments resulted in improvements greater than the control subjects, with some generalization to other cognitive measures	---
Sohlberg & Mateer, 1987	Class II; Single-subject, multiple baseline design	4	CHI, PHI, Aneurysm; 12-72 months p/o; Ages 25-30 years; Severity = 24 hrs-7 weeks LOC	APT; Concurrent intervention related to daily living, prevocational and psychosocial skills 7-9 sessions weekly for 4-8 weeks	PASAT, Spatial Relations Subtest from Woodback	All subjects showed gains after attention training but none after visuospatial processing training.	All improved in dependent living or return to work status

Wood & Fussy, 1987	Class II: Non-randomized, group design	30	TBI	Direct retraining of attention through a computer-based information processing of the visual modality	Two attention behaviors, Two vigilance tests	Results were inconclusive of causation	---
Webster, McCaffrey, & Scott, 1986 as cited in Coelho, DeRuyter, & Stein, 1996	---	2	---	Reaction time practice with performance feedback	---	Reaction time improved	---
Wood, 1986	Class II	2	Severe TBI	Treatment 1: Token reinforcement for selective attention; Treatment 2: Reinforced practice of attention tasks	Frequency of attention-to-task behaviors, Auditory-Verbal Memory	Selective attention improved with token reinforcement. Reinforced practice led to improvements on training tasks, but no changes in other measures. Participants improved their duration of sustained attention and became more efficient at processing information	---
Malec, Jones, Rao, & Stubbs, 1984 as cited in Park & Ingles, 2001	---	1	---	Direct retraining of attention; Practice with verbal repetition task	---	Gains in selective attention noted during conversation	---

Appendix B

APT-3 Progress Tracking Spreadsheet: Hierarchy and Levels

			Effort Rating / Accuracy Percentage																						
Date/(T)Treatment or (H)Homework:																									
Section 1: Attention Domain: Basic Sustained Tasks	Level	Condition																							
Listening for 1 Number	1	Slow																							
	2	Fast																							
Listening for 1 Letter in a word	1	Slow																							
	2	Fast																							
Listening for 1 Noise	1	Slow																							
	2	Fast																							
Listening for 1 Animal Sound	1	Slow																							
	2	Fast																							
Listening for 2 Numbers	3	Slow																							
	4	Fast																							
Listening for 2 Animal Sounds	3	Slow																							
	4	Fast																							
Listening for 2 Numbers Ascending	5	Slow																							
	6	Fast																							
Listening for 2 Numbers Descending	5	Slow																							
	6	Fast																							
Matching Digital and Analog Clocks	7	Slow																							
	8	Fast																							
Watching for multiples of 3 (1-30)	9	Slow																							
	10	Fast																							
Watching for multiples of 3 (1-99)	11	Slow																							
	12	Fast																							
Number comparisons (easy)	13	Slow																							
	14	Fast																							
Number comparisons (hard)	15	Slow																							
	16	Fast																							
Remembering clock times	17	Slow																							
	18	Fast																							

Matching seasons and month words	19	Slow																							
	20	Fast																							
Matching abstract shapes (2 back)	21	Slow																							
	22	Fast																							
Remembering clock times (2 back)	21	Slow																							
	22	Fast																							
Matching animals (2 back)	21	Slow																							
	22	Fast																							
Matching faces and emotion words	19	Slow																							
	20	Fast																							

			Effort Rating / Accuracy Percentage																						
Date/(T)Treatment or (H)Homework:																									
Section II: Executive Control Selective Attention Tasks	Level	Condition																							
Listening for 1 Number	1	S + VM																							
	2	S + WN																							
	3	S +EN																							
	4	S + NN																							
	5	S + AC																							
	6	F + VM																							
	7	F + WN																							
	8	F +EN																							
	9	F + NN																							
	10	F + AC																							
Listening for 1 Letter in a word	1	S + VM																							
	2	S + WN																							
	3	S +EN																							
	4	S + NN																							
	5	S + AC																							
	6	F + VM																							
	7	F + WN																							
	8	F +EN																							
	9	F + NN																							
	10	F + AC																							

Listening for 1 Noise	1	S + VM																							
	2	S + WN																							
	3	S +EN																							
	4	S + NN																							
	5	S + AC																							
	6	F + VM																							
	7	F + WN																							
	8	F +EN																							
	9	F + NN																							
	10	F + AC																							
Listening for 1 Animal sound	1	S + VM																							
	2	S + WN																							
	3	S +EN																							
	4	S + NN																							
	5	S + AC																							
	6	F + VM																							
	7	F + WN																							
	8	F +EN																							
	9	F + NN																							
	10	F + AC																							
Listening for 2 numbers	11	S + VM																							
	12	S + WN																							
	13	S +EN																							
	14	S + NN																							
	15	S + AC																							
	16	F + VM																							
	17	F + WN																							
	18	F +EN																							
	19	F + NN																							
	20	F + AC																							
Listening for 2 Letters in a word	11	S + VM																							
	12	S + WN																							
	13	S +EN																							
	14	S + NN																							
	15	S + AC																							
	16	F + VM																							

	17	F + WN																							
	18	F +EN																							
	19	F + NN																							
	20	F + AC																							
Listening for 2 noises	11	S + VM																							
	12	S + WN																							
	13	S +EN																							
	14	S + NN																							
	15	S + AC																							
	16	F + VM																							
	17	F + WN																							
	18	F +EN																							
	19	F + NN																							
	20	F + AC																							
Listening for 2 Animal sounds	11	S + VM																							
	12	S + WN																							
	13	S +EN																							
	14	S + NN																							
	15	S + AC																							
	16	F + VM																							
	17	F + WN																							
	18	F +EN																							
	19	F + NN																							
	20	F + AC																							
Listening for 2 numbers ascending	21	S + VM																							
	22	S + WN																							
	23	S +EN																							
	24	S + NN																							
	25	S + AC																							
	26	F + VM																							
	27	F + WN																							
	28	F +EN																							
	29	F + NN																							
	30	F + AC																							
Listening for 2 Numbers Descending	21	S + VM																							
	22	S + WN																							

	23	S +EN																						
	24	S + NN																						
	25	S + AC																						
	26	F + VM																						
	27	F + WN																						
	28	F +EN																						
	29	F + NN																						
	30	F + AC																						
Matching Digital and Analog Clocks	31	S + WN																						
	32	S + EN																						
	33	S + NN																						
	34	S + VM																						
	35	S + AC																						
	36	S + VC																						
	37	F + WN																						
	38	F + EN																						
	39	F + NN																						
	40	F + VM																						
	41	F + AC																						
	42	F + VC																						
Watching for multiples of 3 (1-30)	43	S + WN																						
	44	S + EN																						
	45	S + NN																						
	46	S + VM																						
	47	S + AC																						
	48	S + VC																						
	49	F + WN																						
	50	F + EN																						
	51	F + NN																						
	52	F + VM																						
	53	F + AC																						
	54	F + VC																						
Watching for multiples of 3 (1-99)	55	S + WN																						
	56	S + EN																						
	57	S + NN																						
	58	S + VM																						

	59	S + AC																						
	60	S + VC																						
	61	F + WN																						
	62	F + EN																						
	63	F + NN																						
	64	F + VM																						
	65	F + AC																						
	66	F + VC																						
Number comparisons (easy)	67	S + WN																						
	68	S + EN																						
	69	S + NN																						
	70	S + VM																						
	71	S + AC																						
	72	S + VC																						
	73	F + WN																						
	74	F + EN																						
	75	F + NN																						
	76	F + VM																						
	77	F + AC																						
	78	F + VC																						
Number comparisons (hard)	79	S + WN																						
	80	S + EN																						
	81	S + NN																						
	82	S + VM																						
	83	S + AC																						
	84	S + VC																						
	85	F + WN																						
	86	F + EN																						
	87	F + NN																						
	88	F + VM																						
	89	F + AC																						
	90	F + VC																						
Remembering clock times	91	S + WN																						
	92	S + EN																						
	93	S + NN																						
	94	S + VM																						

	95	S + AC																							
	96	S + VC																							
	97	F + WN																							
	98	F + EN																							
	99	F + NN																							
	100	F + VM																							
	101	F + AC																							
	102	F + VC																							
Matching seasons and month words	103	S + WN																							
	104	S + EN																							
	105	S + NN																							
	106	S + VM																							
	107	S + AC																							
	108	S + VC																							
	109	F + WN																							
	110	F + EN																							
	111	F + NN																							
	112	F + VM																							
	113	F + AC																							
	114	F + VC																							
Matching abstract shapes (2 back)	115	S + WN																							
	116	S + EN																							
	117	S + NN																							
	118	S + VM																							
	119	S + AC																							
	120	S + VC																							
	121	F + WN																							
	122	F + EN																							
	123	F + NN																							
	124	F + VM																							
	125	F + AC																							
	126	F + VC																							
Remembering clock times (2 back)	115	S + WN																							
	116	S + EN																							
	117	S + NN																							
	118	S + VM																							

	119	S + AC																							
	120	S + VC																							
	121	F + WN																							
	122	F + EN																							
	123	F + NN																							
	124	F + VM																							
	125	F + AC																							
	126	F + VC																							
Matching animals (2 back)	115	S + WN																							
	116	S + EN																							
	117	S + NN																							
	118	S + VM																							
	119	S + AC																							
	120	S + VC																							
	121	F + WN																							
	122	F + EN																							
	123	F + NN																							
	124	F + VM																							
	125	F + AC																							
	126	F + VC																							
Matching faces and emotion words	103	S + WN																							
	104	S + EN																							
	105	S + NN																							
	106	S + VM																							
	107	S + AC																							
	108	S + VC																							
	109	F + WN																							
	110	F + EN																							
	111	F + NN																							
	112	F + VM																							
	113	F + AC																							
	114	F + VC																							

			Effort Rating/ Accuracy Percentage																					
Date/(T)Treatment or (H)Homework:																								
Section III: Executive Control Working Memory Tasks	Level	Condition																						
2-step serial number calculations	1	PY																						
	2	PN																						
3-step serial number calculations	3	PY																						
	4	PN																						
Number Sequences (Reverse) (5, 10, 15, 20)	5	PY + 3E																						
(5, 10, 15, 20)	6	PY + 4E																						
(5, 10, 15, 20)	7	PY + 4H																						
(5, 10, 15, 20)	8	PY + 5H																						
(5, 10, 15, 20)	9	PN + 3E																						
(5, 10, 15, 20)	10	PN + 4E																						
(5, 10, 15, 20)	11	PN + 4H																						
(5, 10, 15, 20)	12	PN + 5H																						
Number Sequences (Ascending) (5, 10, 15, 20)	13	PY + 3E																						
(5, 10, 15, 20)	14	PY + 4E																						
(5, 10, 15, 20)	15	PY + 4H																						
(5, 10, 15, 20)	16	PY + 5H																						
(5, 10, 15, 20)	17	PN + 3E																						
(5, 10, 15, 20)	18	PN + 4E																						
(5, 10, 15, 20)	19	PN + 4H																						
(5, 10, 15, 20)	20	PN + 5H																						
Number Sequences (Descending) (5, 10, 15, 20)	13	PY + 3E																						
(5, 10, 15, 20)	14	PY + 4E																						
(5, 10, 15, 20)	15	PY + 4H																						
(5, 10, 15, 20)	16	PY + 5H																						
(5, 10, 15, 20)	17	PN + 3E																						
(5, 10, 15, 20)	18	PN + 4E																						
(5, 10, 15, 20)	19	PN + 4H																						
(5, 10, 15, 20)	20	PN + 5H																						
Number Sequences (Add 3) (5, 10, 15, 20)	21	PY + 3E																						
(5, 10, 15, 20)	22	PY + 4E																						
(5, 10, 15, 20)	23	PY + 4H																						
(5, 10, 15, 20)	24	PY + 5H																						

(5, 10, 15, 20)	25	PN + 3E																							
(5, 10, 15, 20)	26	PN + 4E																							
(5, 10, 15, 20)	27	PN + 4H																							
(5, 10, 15, 20)	28	PN + 5H																							
Number Sequences (Subtract 2) (5, 10, 15, 20)	21	PY + 3E																							
(5, 10, 15, 20)	22	PY + 4E																							
(5, 10, 15, 20)	23	PY + 4H																							
(5, 10, 15, 20)	24	PY + 5H																							
(5, 10, 15, 20)	25	PN + 3E																							
(5, 10, 15, 20)	26	PN + 4E																							
(5, 10, 15, 20)	27	PN + 4H																							
(5, 10, 15, 20)	28	PN + 5H																							
Word Sentences (Reverse) (5, 10, 15, 20)	29	PY + 4																							
(5, 10, 15, 20)	30	PY + 5																							
(5, 10, 15, 20)	31	PY + 6																							
(5, 10, 15, 20)	32	PN + 4																							
(5, 10, 15, 20)	33	PN + 5																							
(5, 10, 15, 20)	34	PN + 6																							
Word Sentences (Alphabetical) (5, 10, 15, 20)	35	PY + 4																							
(5, 10, 15, 20)	36	PY + 5																							
(5, 10, 15, 20)	37	PY + 6																							
(5, 10, 15, 20)	38	PN + 4																							
(5, 10, 15, 20)	39	PN + 5																							
(5, 10, 15, 20)	40	PN + 6																							
Word Sentences (Progressive) (5, 10, 15, 20)	35	PY + 4																							
(5, 10, 15, 20)	36	PY + 5																							
(5, 10, 15, 20)	37	PY + 6																							
(5, 10, 15, 20)	38	PN + 4																							
(5, 10, 15, 20)	39	PN + 5																							
(5, 10, 15, 20)	40	PN + 6																							

			Effort Rating / Accuracy Percentage																						
Date/(T)Treatment or (H)Homework:																									
Section IV: Attention Domain: Executive Suppression	Level	Condition																							

Happy-Sad	1	S + IB																						
	2	S + IV																						
	3	F + IB																						
	4	F + IV																						
Falling-Rising	1	S + IB																						
	2	S + IV																						
	3	F + IB																						
	4	F + IV																						
High-Low	1	S + IB																						
	2	S + IV																						
	3	F + IB																						
	4	F + IV																						
Adult-Child	1	S + IB																						
	2	S + IV																						
	3	F + IB																						
	4	F + IV																						
Fast-Slow	1	S + IB																						
	2	S + IV																						
	3	F + IB																						
	4	F + IV																						
One-Two voices	1	S + IB																						
	2	S + IV																						
	3	F + IB																						
	4	F + IV																						
Serious-Silly	1	S + IB																						
	2	S + IV																						
	3	F + IB																						
	4	F + IV																						
Left-Right	1	S + IB																						
	2	S + IV																						
	3	F + IB																						
	4	F + IV																						
Above-Below	1	S + IB																						
	2	S + IV																						
	3	F + IB																						
	4	F + IV																						

Big-Small	1	S + IB																						
	2	S + IV																						
	3	F + IB																						
	4	F + IV																						
Solid-Hollow	1	S + IB																						
	2	S + IV																						
	3	F + IB																						
	4	F + IV																						
Numbers-Digits	1	S + IB																						
	2	S + IV																						
	3	F + IB																						
	4	F + IV																						
Circle-Triangle-Square in shapes	5	S + IB																						
	6	S + IV																						
	7	F + IB																						
	8	F + IV																						
Word Shapes	5	S + IB																						
	6	S + IV																						
	7	F + IB																						
	8	F + IV																						
High-Mid-Low	5	S + IB																						
	6	S + IV																						
	7	F + IB																						
	8	F + IV																						
Left-Right-Center	5	S + IB																						
	6	S + IV																						
	7	F + IB																						
	8	F + IV																						
North-South-East-West	9	S + IB																						
	10	S + IV																						
	11	F + IB																						
	12	F + IV																						
Left-Right-Top-Bottom	9	S + IB																						
	10	S + IV																						
	11	F + IB																						
	12	F + IV																						

Word Distractions	13	S + IB																						
	14	S + IV																						
	15	F + IB																						
	16	F + IV																						

			Effort Rating / Accuracy Percentage																					
Date/(T)Treatment or (H)Homework:																								
Section V: Executive Control Alternating Tasks	Level	Condition																						
Happy-Sad	1	Slow																						
	2	Fast																						
High-Low	1	Slow																						
	2	Fast																						
Loud-Soft	1	Slow																						
	2	Fast																						
Adult-Child	1	Slow																						
	2	Fast																						
Fast-Slow	1	Slow																						
	2	Fast																						
One-Two	1	Slow																						
	2	Fast																						
Serious-Silly	1	Slow																						
	2	Fast																						
Left-right	1	Slow																						
	2	Fast																						
Above-Below	1	Slow																						
	2	Fast																						
Big-Small	1	Slow																						
	2	Fast																						
Solid-Hollow	1	Slow																						
	2	Fast																						
Circle-Triangle-Square	3	Slow																						
	4	Fast																						
Word Shapes	3	Slow																						
	4	Fast																						

High-Mid-Low	3	Slow																							
	4	Fast																							
Left-Right-Center	3	Slow																							
	4	Fast																							
North-South-East-West	5	Slow																							
	6	Fast																							
Left-Right-Top-Bottom	5	Slow																							
	6	Fast																							
Word Directions	7	Slow																							
	8	Fast																							

Speed: S = Slow; F = Fast
Distracters: WN = White Noise; EN = Environmental Noise; NN = Newscast Noise; VM = Visual Motion; AC = Auditory Competition; VC = Visual Competition
Prompting (Visual): PY = Yes prompting; PN = No prompting
Stimuli: 5S = 5 presentations; 10S = 10 presentations; 15S = 15 presentations; 20S = 20 presentations
Complexity: 3 = 3 items, 0-30; 4E = 4 items, 0-30; 4H = 4 items, 0-100; 5 = 5 items, 0-100
Input: IB = Button; IV = Verbal

Appendix C
Strategies Used for Meta-Cognition in Treatment

- Watch lips of conversation partner
- Focus eyes on part of target
- To a breath to relax/refocus
- Visually organize
- Relax
- Verbalize aloud/to self
- Visualize
- Repeat verbally
- Organize into groups
- Assess what focus feels like
- "Reset" attention, "Start over"
- Abbreviate self-cues
- Get distracted thoughts out (e.g. notes)
- "Spit it out!", "Follow gut"
- "Tunnel vision"
- "Tunnel ears"
- Gesturing w/ or w/o verbalization
- Allow time to adjust
- Concentrate on changes

Appendix D
Functional Goals

Selective Attention

Goal: I will be able to ignore background noises better in order to pay attention to the task I want to focus on.

+2	
+1	
0	
-1	
-2	

Goal tracking:

Date:	Task	Type of distracter	Volume of distracter noise	Time spent	"On task" Score (1-10)	Cost of fatigue (1-10)	Strategies used/Notes:
5/7	*Reading bible*	*Cello music*	*9*	*5 min*	*2*	*7*	*Quite difficult*
5/8	*""*	*Orchestra w/ voice*	*9*	*6*	*4*	*7*	*Read twice*
5/9	*""*	*""*	*9*	*6.5*	*5*	*5*	*Read twice; home relaxed*
5/10	*""*	*""*	*9*	*10*	*5*	*4*	*3 x, first w/o music*
5/14	*""*	*""*	*9*	*3*	*7*	*4*	*In morning after other reading*
5/31	*Email*	*iTunes*	*?*	*15*	*5*	*8*	*Email w/ Bose headphones*
6/4	*""*	*""*	*?*	*25*	*7*	*7*	*""*
6/11	*""*	*Store music*	*?*	*22*	*7*	*5*	
							**Strategies used in "distracter" tasks*

Check in frequency: *Weekly*

Working Memory

Goal: I will be able to read one chapter of a book and feel as though I understood it.

+2	
+1	
0	
-1	
-2	

Goal tracking:

Date:	Type of book	Time spend reading	Amount understood (1-10)	Strategies used/Notes:
5/13	*"Hope"*	*16 min*	*6*	*"Hold and apply"; highlight*
5/14	*""*	*27*	*7*	
5/18	*""*	*15*	*6*	*Stop and think strategy*
5/20	*""*	*15*	*4*	
5/24	*""*	*20*	*7*	*Re-read and take notes on main points- this works well*
5/29	*""*	*15*	*7*	*""*
5/31	*""*	*15*	*7*	*""*
6/3	*""*	*16*	*7*	
6/7	*""*	*20*	*7*	
6/11	*""*	*21*	*6*	
6/13	*""*	*21*	*7*	

Check in frequency: *Weekly*

Alternating Attention

Goal: I will improve my ability to quickly switch my attention between tasks

+2	
+1	
0	
-1	
-2	

Goal tracking:

Date:	Tasks	Approximate time spent on each task	Time required to refocus on new task (%)	Strategies used/Notes:
5/19	*Baseball/Spanish worksheet*	*-no game-*	-	-
5/14	*“”*	*21/3*	*-30 sec to start baseball -immediate to start Spanish*	*Hard to switch- too much effort, just listened after*

Check in frequency: *Weekly*

Appendix E

APT-3 Task Tracking Spreadsheet

Client Name:							Attention Domain:			
							Task:			
H/T	Date	Version*	Predictions:	Strategies:	Reflections:	Effort	Motivation	Time	Accuracy	Error Pattern

*Version Codes:
Speed: S = Slow; F = Fast
Distracters: WN = White Noise; EN = Environmental Noise; NN = Newscast Noise; VM = Visual Motion; AC = Auditory Competition; VC = Visual Competition
Prompting (Visual): PY = Yes prompting; PN = No prompting
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