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Treatment effects of attention process training for an individual with idiopathic Parkinson's disease

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TREATMENT EFFECTS OF ATTENTION PROCESS TRAINING FOR AN INDIVIDUAL WITH IDIOPATHIC PARKINSON'S DISEASE

A Thesis

Submitted to the Graduate Faculty of the Louisiana State University and Agricultural and Mechanical College in partial fulfillment of the requirements for the degree of Master of Arts

in

The Department of Communication Sciences and Disorders

By
Kristen Michelle Ferguson
B.S., The University of Texas at Austin, 2010
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ABSTRACT

Purpose: The purpose of this study was to determine the treatment efficacy of the Attention Process Training (APT; Sohlberg & Mateer, 2005), a therapeutic protocol designed for individuals who have sustained a traumatic brain injury (TBI), on a person with Parkinson’s disease to determine if improvement of various attention processes and memory recall could be improved.

Methods: We designed a phase I, multiple baseline A1-B-A2-A3, single-subject study with one participant diagnosed with idiopathic PD and self-reported attention impairments. We used Attention Process Training (APT) protocol (Sohlberg & Mateer, 2005) to train attention process 120-minutes per session, one time per week for 6 sessions.

Results: The participant demonstrated a large improvement in sustained attention for both percent accuracy (A1 to A2 d=5.196; A1 to A3 d = 13.279; A2 to A3 d=1.443) and timed performance (A1 to A2 d=2.952; A1 to A3 d = 3.153; A2 to A3 d=0.287). While treating sustained attention, we continued to probe selective, alternating and divided attention. Carryover improvement was noted with selective attention percent accuracy (A1 to A2 d=.091; A1 to A3 d=2.817; A2 to A3 d=1.299) and timed performance (A1 to A2 d=.690; A1 to A3 d=1.044; A2 to A3 d=1.598), and divided attention percent accuracy (A1 to A2 d=1.225; A1 to A3 d = 1.225; A2 to A3 d=2.860) and timed performance (A1 to A2 d=2.041; A1 to A3 d = 1.225; A2 to A3 d=1.155).

The results of the TEA indicated an improvement or maintenance in the scaled scores of each subtest. Performance increased in the following scores: OSPAN absolute
scores, accuracy errors, and math errors; RSPAN speed errors, math errors, and total correct.

**Discussion**: Results demonstrated that training sustained attention using the *APT* tasks resulted in sizeable effects when delivered at high intensity (120 minutes per session) one time per week for six weeks. We saw improvement on the untrained selective and divided attention, but not alternating attention, which should have been easier, according the *APT* hierarchy. We cannot generalize these findings. However, the results give us evidence to continue treatment development.
CHAPTER 1. INTRODUCTION

Parkinson’s Disease (PD), a progressive, degenerative neurologic disorder, affects approximately half a million individuals in the United States (National Institute of Neurological Disorders and Stroke [NINDS], 2012; Lewis, LaPointe, Murdoch, & Chenery, 1998). British physician, James Parkinson in 1812, first described PD as a progressive, chemically-based disease of the basal ganglia (NINDS, 2012; Bhatnagar, 2008). PD is characterized, specifically, by a depletion of dopamine in the substantia nigra, the presence of Lewy bodies, and a disruption of the circuitry connecting the basal ganglia and frontal lobe regions (Murray & Clark, 2006; Watts, 2004; Murray, 2008). The classic symptoms of PD include tremor, bradykinesia, rigidity, and impaired balance (Watts, 2004; NINDS, 2012). In addition, it has been reported that individuals with PD demonstrate cognitive deficits in the following domains: visuospatial abilities, memory, attention, executive planning, and language (Murdoch & Whelan, 2009; Cooper, Sagar, Jordan, Harvey, & Sullivan, 1991; Dubois, Boller, Pillon, & Agid, 1991; Levin & Katzen, 1995). Unfortunately, there is little research regarding the relationship of cognitive status to the performance of language on individuals with PD (Lewis et al., 1998; Murray, 2008).

Researchers have demonstrated the motor and cognitive deficits of PD; however, limited research has examined language abilities and its relation to cognition in people with PD (Murray, 2008). Although, language deficits have typically been associated with more advanced stages of PD, such deficits have become more prevalent (Bayles, Tomoeda, Wood, Cruz, Azuma, & Montgomery, 1997; Lewis et al., 1998; Murray, 2008). Bayles (1990) suggested that the prominent language deficits in individuals with
PD were actually a result of dysfunction in the cognitive domains of attention, memory, and executive function. More recently, in a review of the literature, Altman and Troche (2011) reported on a study where in PD patients with below normal cognitive status showed deficits in naming, definition abilities, verb generation, interpreting ambiguity, and figurative language.

Furthermore, language deficits involving comprehension in individuals with PD appear more frequently when language processing depends on inhibition of completing tasks or within tasks involving high working memory demands (Murray, 2008; Altman & Troche, 2011). Such results suggest that clinical treatment of cognition may be beneficial to individuals with PD as the circuitry disruption between the basal ganglia and frontal lobe may affect attention processes (Murray, 2008). Consequently, researchers have postulated that the dopamine reduction in the basal ganglia is linked to deficits in cognitive switching, the ability to change from one mental task that guides behavior to the next mental task, and attention filtering, the ability to filter out irrelevant tasks or information (Murdoch & Whelan, 2009; Hayes, Davidson, Keele, & Rafal, 1998).

Cognitive impairments are evident in 72% of individuals with PD due to the basal ganglia’s motor and cognitive connectivity with the cerebral cortex (Cooper, Sagar, Jordan, Harvey, & Sullivan, 1991; Duffy, 2005). Researchers have hypothesized that the basal ganglia’s motor and cognitive connectivity with cerebral cortex may cause deficits in visuospatial processes, attention, memory and overall executive functioning (Lewis et al., 1998).

The cognitive deficits demonstrated by individuals with PD are similar to the cognitive deficits demonstrated by individuals who suffer from frontal lobe damage due
to diffused axonal injury as a result of traumatic brain injury (TBI) (Lees, & Smith, 1983; Bowen, 1976). TBI is the result of direct impact to the brain via an external force (Murray & Clark, 2006). This kind of impact to the brain causes various emotional, cognitive, physical, and behavior deficits. Cognitive impairments are the most salient impairments seen in patients with TBI particularly in the domains of attention, memory, and executive functioning. Attention impairments are present in the vast majority of TBI patients regardless of severity of the injury. Since researchers have hypothesized that attention is the fundamental cognitive process upon which all these deficits build, it has the potential to interfere with rehabilitation of other cognitive deficits such as memory, executive functioning, and communication deficits such as topic maintenance and topic switching (Sohlberg & Mateer, 2001; Murray & Clark, 2006; Murdoch & Whelan, 2009).

In response to the need to decrease attention deficits found in individuals with TBI, various attention treatments have been devised. Evidence supports Attention Process Training (APT) as a treatment program to remediate attention deficits in TBI patients (Sohlberg & Mateer, 1987; Pero, Incoccia, Caracciolo, Zoccolotti, & Formisano, 2006). APT is a systemic training program that aims to improve attention deficits, and, hopefully, other cognitive and communication impairments, by training the areas of attention impaired by TBI: focused attention, sustained attention, selective attention, alternating attention, and divided attention (Sohlberg, Johnson, Paule, Raskin, & Mateer, 2001; Pero et al., 2006). Although, the APT program was specifically designed for patients with TBI, we wondered if this program might benefit individuals with PD since research has consistently reported attention deficits in that group as well. In this study,
we aimed to determine the treatment efficacy of the APT to improve attention deficits in an individual with idiopathic PD.
CHAPTER 2. REVIEW OF THE LITERATURE

We developed this study based on four areas of research: the neuropathology of PD; the cognitive deficits associated with PD based on neuropsychological testing; current theories about attention and working memory; and, treatment efficacy of APT in other populations. The literature will be reviewed in this order.

2.1 The Neuropathology of Parkinson’s Disease

PD is the result of a progressive deterioration of the substantia nigra, one of the subcortical structures in the basal ganglia. The substantia nigra produces dopamine, the neurotransmitter used to project neurons from the substantia nigra and the corpus striatum to produce smooth movement. Therefore, PD is characterized by motor impairments (Murray & Clark, 2006; Zgaljardic, Borod, Foldi, Mattis, Gordon, Feigin, & Eidelberg, 2006; NINDS, 2012). Additionally, low levels of dopamine have been linked to impairment in cortical areas such as the frontal lobe (Owen, 2004; Murdoch & Whelan, 2009).

The motor impairments of PD include tremor, rigidity, bradykinesia, and postural instability (NINDS, 2012; Watts & Koller, 2004; Bhatnagar, 2008). Tremor consists of involuntary, slow, resting oscillations or trembling in the hands, arms, legs, jaw or head (Watts & Koller, 2004; NINDS, 2012). Rigidity is an increase in muscle tone or stiffness that causes ratchet-like jerks in the limbs and trunk (Watts & Koller, 2004; NINDS, 2012; Bhatnagar, 2008). Bradykinesia refers to slowed movement execution (Watts & Koller, 2004; NINDS, 2012; Bhatnagar, 2008). Non-motor symptoms include depression, emotional or personality changes, sleep and sexual disturbances, problems with chewing
and swallowing, hypokinetic dysarthria, and cognitive disturbances such as problems with executive functioning, memory, visuospatial functions, and dementia (Watts & Koller, 2004; NINDS, 2012; Duffy, 2005). Evidence has shown that some of these non-motor symptoms may be caused by the degeneration of the locus coeruleus, the noradrenaline nucleus of the brain responsible for producing norepinephrine (Rommelfanger & Weinshenker, 2007). Norepinephrine is a neurotransmitter similar to dopamine that is the messenger for the sympathetic nervous system (NINDS, 2012). Furthermore, scientists have postulated that the four cardinal motor symptoms of PD are most frequently accompanied by cognitive impairments due to degeneration of the substantia nigra, and thus, resulting from dopamine depletion in the basal ganglia (BG). The dopamine depletion in the BG subsequently affects the connective circuitry from the BG to the cerebral cortex through discrete circuits or loops (Owen, 2004; Middleton & Strick, 2000).

Even though the etiology of idiopathic PD is unknown, research has uncovered information about PD impairments through exploration of the BG and its circuitry. The BG is made up of three nuclei: caudate nucleus, putamen, and globus pallidus (Bhatnagar, 2008). The substantia nigra and subthalamic nucleus are functionally connected to the BG and work as a whole with the main BG nuclei to complete motor functions within the motor cortex, cerebellum, and brainstem (Bhatnagar, 2008). There are four major loops or circuits in the basal ganglia segregated into motor and complex/non-motor circuits throughout the BG and thalamus (Bhatnagar, 2008; Zgaljardic et al., 2006). The two main loops known to contribute to cognitive and language functions are the dorsolateral prefrontal BG loop and the anterior cingulate
cortex loop (Crosson, 1992; Murdoch & Whelan, 2009; Zgaljardic et al., 2006; Stuss & Knight, 2002). The dorsolateral prefrontal loop mediates cognitive executive functions and the anterior cingulate cortex loop regulates motivation and attention (Zgaljardic et al., 2006). Due to the segregations of these BG-thalamo-cortical (BG-T-C) circuits, evidence suggests that the BG and subcortical structures serve a functional role in motor processes, behavior, cognition, language, and limbic processes and that the BG’s principle target for outflow is the frontal lobes (Crosson, 1992; Zgaljardic et al., 2006; Murdoch & Whelan, 2009; Owen, 2004). Researchers have hypothesized that the interruption of dopamine in these circuits to the frontal lobes causes cognitive impairments in individuals with PD (Crosson, 1992; Owen, 2004; Zgaljardic et al., 2006; Stuss & Knight, 2002). See figure 1.

Figure 1. Represents the basal ganglia-thalamo-cortical (BG-T-C) circuits that control executive cognition, impulse control and mood regulation on the left, and motivation and attention on the right (Royall, 2004; Juri, Rodriguez-Oroz, & Obseso, 2010)
2.2 Cognitive Deficits associated with Parkinson’s Disease

Cognitive impairments demonstrated by individuals with PD resemble the cognitive impairments demonstrated by individuals with frontal lobe damage and includes executive functioning deficits possibly due to a disruption of dopamine in the BG-T-C circuits (Owen, 2004; Cooper, Sagar, Jordan, Harvey, & Sullivan, 1991; Taylor, Saint-Cyr, & Lang 1986; Stuss & Knight, 2002). Numerous studies have investigated dopamine role through BG-T-C circuitry and its contribution to cognition (Owen, 2004; Lees & Smith, 1983; Dubois et al., 1994). According to Owen (2004), the nigrostriatal tract and the striatum are the primary areas for dopamine loss. This suggests that cognitive and executive deficits in PD may not be a result of frontal lobe dysfunction per se, but instead a result of dopamine depletion in the striatum, which subsequently affects the normal neuronal activation that dopamine elicits through the BG-T-C circuitry (Owen, 2004; Stuss & Knight, 2002). Other research suggests that the cognitive impairments demonstrated by people with PD results from dopamine depletion in the frontal cortex and degeneration of the mesocortical dopamine tract, which serves as a relay to the frontal lobes and various cortical areas (Scatton, Javoy-Agid, Rouquier, Dubois, & Agid, 1983). Furthermore, Agid, Ruberg, Dubois, and Pillion (1987) found that decreased dopamine in the nigrostriatal dopamine tract was severely affected in individuals with PD. Even though numerous studies have investigated the role dopamine plays in BG and its relation to cognition, no one has yet definitively explained dopamine’s precise contribution to cognition (Nieoullon, 2002). However, more recent literature supports Owen’s (2004) claim that the result of dopamine depletion from the BG impairs the normal flow of dopamine through the BG-T-C circuitry, specifically, the
anterior cingulate cortex, which regulates attention processes (Stuss & Knight, 2002; Zgaljardic et al., 2006).

Various studies have suggested cognitive deficits due to the dopamine depletion in the BG-T-C circuitry occur even in the early stages of PD (Nieoullon, 2002; Stuss & Knight, 2002). The most salient cognitive deficits found in people with PD include impaired visuo-spatial processes and impaired ability to shift conceptual tasks and maintain mental sets, suggesting that damage to the BG-T-C circuits involves the BG and dopamine depletion (Nieoullon, 2002). In a study conducted by Bondi, Kaszniak, Bayles, & Vance (1993), the authors used both visuospatial and frontal system tasks to test cognition in non-demented PD subjects and found that once performance on frontal system tasks improved visuospatial deficits showed significant improvement. In addition, PD patients have impaired executive functioning skills (Nieoullon, 2002; Dubois & Pillon, 1997). Typically, executive functioning deficits have been reported in people with frontal lobe damage (Dubois & Pillon, 1997; Kane & Engle, 2002). Specifically, Dubois and Pillon (1997) reported that individuals with PD also demonstrate impairments with tasks that require internal guided behavior such as rule-finding and concept formation tasks, set-shifting tasks, set-maintenance tasks, and problem-solving tasks.

With regard to more basic cognitive processes, individuals with PD demonstrate deficits in both attention and working memory domains (Dubois & Pillon, 1997; Lewis et al., 1998; Murdoch & Whelan, 2009; Kane & Engle, 2002). Owens (2004) found that individuals with PD demonstrated difficulty manipulating set-stimuli such as, recalling letters of the alphabet and rearranging them in the order presented. Additionally, individuals with PD have difficulty with recalling word lists and ordering or sequencing
words (Nieoullon, 2002; Dubois et al., 1994; Kane & Engle, 2002). Without intact attention and memory processes, individuals cannot complete higher-level cognitive tasks such as executive functioning and visuospatial processing.

2.3 Attention and Working Memory Processes

Attention is defined as a multidimensional process that enables the brain to focus on incoming stimuli based on components of alertness or readiness to respond, vigilance or capacity to attend over a period of time, and, lastly, the capacity to select relevant stimuli needed for conscious processing (Ponsford & Kinsella, 1992). Sohlberg and Mateer’s (1987) attention process model orders attention hierarchically into four levels: sustained, selective, alternating, and divided. Sustained attention is the ability to maintain focus on a stimulus during continuous or repetitive activities. Selective attention is the ability to selectively attend to target stimuli while ignoring peripheral non-target stimuli. Alternating attention refers to the ability to switch focus between two or more sets of stimuli during different cognitive tasks. Divided attention is the ability to simultaneously focus on two or more stimuli concurrently (Sohlberg et al., 2001; Weber, 1990).

According Schneider and Shiffrin’s (1977) model, attention has two processing formats: automatic and controlled. Automatic processing requires little subject effort and permits little self-control. Contrarily, controlled processing requires subject effort and requires a large amount of self-control (Schneider, Dumais, Shiffrin, 1982). In this study, we will focus on controlled attention processing, which requires conscious attention with limited capacity and rate (Ponsford & Kinsella, 1992). If an individual has limited control processing abilities then the result is limited attention capacity (Weber, 1990).
Research suggests that individuals who have impaired attention control experience slow performance, difficulty learning new material, difficulty recalling information, and slowed self-regulation (e.g. the inability to hold mental representation of self) (Ponsford & Kinsella, 1992; Weber, 1990; Stuss & Knight, 2002). As mentioned earlier, attention deficits are commonly in TBI patients with diffused axonal injury and frontal lobe lesion (Pero et al., 2006). Similar attention deficits are also seen in individuals with PD, although due to different neuropathology (Owen, 2004; Lees, & Smith, 1983; Bowen, 1976). Research indicates that TBI patients with frontal lobe damage exhibit extreme deficits in information processing, attention, memory, and executive functioning, psychosocial interaction, and personality (Stuss & Knight, 2002; Van Zomeren, Brouwer, & Deelman, 1984; Stuss, Stethem, Hugenholtz, Picton, Pivik, & Richard, 1989; Levin & Goldstein, 1986; Crosson, Novack, Trenerry, & Craig, 1989; Mattson, & Levin, 1990; Stuss & Gow, 1992). With the exception of psychosocial disruption and personality change, individuals with PD demonstrate the same cognitive deficits (Stuss & Knight, 2002). Ponsford and Kinsella (1988) suggested that frontal lobe dysfunction reduces information processing control rate, which in turn reduces the individual’s information processing capacity. Deficits in information processing control and capacity directly contribute to attention impairments in patients with frontal lobe injury. These deficits cause difficulty in the ability to attend to specific stimuli, alternate focus between two stimuli, and maintain conversation topics. In addition, deficits in information processing capacity cause problems with sustained attention. When limited amounts of control and capacity are available other processes are affected and, therefore, learning and retrieval are also limited (Russell & D’Hollosy, 1992). The limited learning
and retrieval then affects memory. This evidence demonstrates that reduced attention produces an impairment of memory in brain injury patients and normal subjects (Russell & D’Hollosy, 1992).

Literature also contains evidence that attention control serves as the foundation of working memory capacity, the small amount of information one can store in the brain, attend to, and access freely at any given time (Cowan, 2005). Individuals need intact attention control and working memory in language comprehension tasks to recall previous parts of the message (Cowan, 2005). McNab and Klingberg (2008) conducted an fMRI study on 25 participants ages 19 to 33 years in an attempt to identify the neural basis for the control access of working memory storage. The researchers’ goal was to reveal a specific mechanism that exerted attention control over working memory. The fMRI results revealed a combined activation of the frontal lobe and BG. They found that a portion of the frontal lobe and dopamine receptors in the BG were central to information stored in working memory. These findings reveal that the frontal lobe and the BG control attention and working memory, which confirms that attention and working memory impairments in PD are due to dopamine depletion in the BG-T-C circuitry.

Colman, Koerts, Van Beilen, Leenders, Post, and Bastiaanse (2009) presented further evidence to support the theory that attention and working memory impairments in PD are due to due to dopamine depletion in the BG-T-C circuitry in a study that examined cognitive deficits in 28 individuals with PD and 28 matched controls. Participants provided an inflected verb within the context of a sentence and completed a battery of cognitive tests. The authors reported that verb production in PD was affected when participants switched from past to present tense without cueing. They also reported
that tense option in the verb generation task correlated with working memory and task switching measures. These results provide further evidence that language deficits in individuals with PD appear more frequently when language processing depends on tasks involving high demands of working memory, which requires intact attention processes.

Other studies support the idea that attention is the foundation upon which working memory functions. For example, studies have demonstrated that people need basic levels of attention to control and maintain task-relevant information and remain actively engaged to prevent attending to distractions (Engle & Kane, 2004; Kane, Conway, Hambrick, & Engle, 2007). In accordance, Unsworth & Spillers (2010) found that both attention control and secondary memory (controlled search) were important components of working memory. The authors recruited 181 subjects and used various attention control tasks, secondary memory tasks, and working memory tasks to examine if working memory was controlled by attention control, secondary abilities, or both. Attention control tasks included anti-saccade, arrow flankers, *Stroop Test* (Stroop, 1935; Golden, 1978), and Psychomotor Vigilance Task (PVT) (Dinges & Powell, 1985). Secondary tasks included delayed free recall unrelated words, delayed free recall of semantically related words, picture source-recognition, continual distractor free recall, verbal fluency, fluid intelligence tasks, number series, and verbal analogies. The working memory tasks used included were Operation Span (OSPAN), Symmetry Span (SYMPSPAN), and Reading Span (RSPAN) (Unsworth & Spillers, 2010). The study’s main limitation resulted because the investigators only examined attention control and secondary memory and did not include all of the constructs needed to explain working memory capacity such as active maintenance and primary memory (short-term memory). However, their
research suggested that attention control is the foundation of working memory. They concluded that attention deficits may not be recognized, or may be misdiagnosed as memory impairments (Unsworth & Spillers, 2010; Ponsford, 1988; Sohlberg & Mateer, 1987). Furthermore, Russell and D’Hollosy (1992) found that both short-term and long-term memory rely on attention processes. From this body of evidence, we understand that it is necessary for attention processes to be focused during initial learning in order to recall the information later (Cowan, 2005).

The literature reviewed provides evidence that attention processes form the foundation for memory processes. Therefore it seems reasonable to suggest that treating attention processes might benefit those demonstrating memory deficits. PD is by definition described as movement disorder. However, researchers have demonstrated that cognitive deficits, specifically attention, are non-motor deficits associated with PD (Murdoch & Whelan, 2009). Individuals with PD most often demonstrate impairment in switching cognitive sets, controlling and/or performing automatic tasks, sustained attention, impairment of attention capacity, and working memory (Brown & Marsden, 1988; Downes, Roberts, Shakian, Evenden, Morris, and Robbins, 1989; McNab & Klingberg, 2007). As discussed earlier, attention processes are the foundation upon which higher-level cognitive processes like executive functioning are built. Furthermore, the attention impairments demonstrated by individuals with PD are similar to those demonstrated by individuals who have experienced a frontal lobe injury from TBI (Cousins, Hanley, Davies, Turnbull, and Playfer, 2000; Piccirilli Alessandro, Finali, Piccinin, and Agostini, 1989). Finally, research has demonstrated that beginning with
attention, cognitive deficits can be retrained through a hierarchy of interactive functions (Sohlberg et al., 2001).

**2.4 Attention Process Training**

Attention deficits associated with frank brain injury require specific training administered in a hierarchical manner (i.e. training evolves from easy to difficult tasks) to demonstrate improvement, particularly when basic functions of attention are involved (Sturm, Willmes, Orgass, & Hartje, 1997). Attention deficits are often misdiagnosed in patients and seem to appear solely as memory impairments (Sohlberg & Mateer, 1987). Sohlberg and Mateer (2005) hypothesized that by training attention these supposed memory impairments could be resolved. In order to address attention deficits in patients, Sohlberg and Mateer (2005) produced the *APT*, a hierarchical, multilevel treatment program designed to improve deficits in attention processes following TBI. It is based on cognitive processing models, neuroanatomical models, factor analytic models of attention, and clinical models of attention. The *APT* program defines attention as a multidimensional cognitive domain consisting of four levels of attention: focused attention, sustained attention, selective attention, alternating attention, and divided attention. See Figure 2.

The first level of the *APT*, *focused attention* is defined as the ability to respond or focus on specific visual, auditory, or tactile stimuli (Sohlberg & Mateer, 2005). For example, in the standard *Stroop Test* (Stroop, 1935; Golden, 1978), where an individual is presented with a string of words in different colors and asked to name the ink color (Yantis & Johnston, 1990). The task is completed at a faster rate if the word spells the ink color; consequently, the task is completed at a slower rate if the word spells a color.
different than the ink color (Yantis & Johnston, 1990). The second level, *sustained attention* is the ability to maintain focus on a stimulus during continuous or repetitive activities (Sohlberg & Mateer). *Sustained attention* tasks involve the selection of a target stimulus from various auditory stimuli and cancellation tasks such as, crossing out target letters/numbers from a group of presented stimuli. The third level, *selective attention* is the ability to selectively attend to target stimuli while ignoring peripheral non-target stimuli. *Selective attention* tasks include the ability to maintain cancellation task when simultaneously presented with distractor stimuli. *Alternating attention* refers to the ability to switch focus between two or more sets of stimuli during different cognitive tasks. The individual is required to select two different target stimuli from cancellation tasks. The final level of attention, *divided attention* is the ability to simultaneously focus on two or more stimuli concurrently (e.g. multitask). For example, an individual listens to auditory stimuli and identifies target stimuli, while simultaneously completing another activity.

Specific attention deficits must be identified to select the attention training tasks needed to address the specific level of attention. Once tasks are selected, 50% accuracy must be obtained and tasks will be repeated until 85% accuracy is achieved. Once 85% accuracy is achieved, the next task in the hierarchy will be presented. See Figure 2.

*APT* produced significant improvements in TBI patients’ ability to use coping strategies to deal with cognitive deficits (Pero et al., 2006). Pero et al. (2006) evaluated the efficacy of *APT* on two severe TBI subjects. Results indicated a significant improvement in attention especially at the selective level of attention (Pero et al., 2006). Another study by Sohlberg, McLaughlin, Pavese, Heidrich, and Posner (2000), compared the efficacy of *APT* to brain injury education deemed to eliminate attention impairments
in TBI subjects. Fourteen subjects were divided into two groups. One group received ten weeks of APT training and the other group received ten weeks of brain injury education. Study results demonstrated the group who received APT showed improvements in performance on a variety of tasks related to attention and executive functioning; whereas, the second group that received brain injury education demonstrated improvements in psychosocial functioning and self-reports (Sohlberg et al., 2005).

Contrarily, in a study conducted by Park, Proulx, and Towers (1999), the authors suggested that APT resulted in learning specific skills and did not actually improve attention processes. The authors compared performance on two neuropsychological tests: the Paced Auditory Serial Addition Task (PASAT; Gronwell, 1977), a test used to

Figure 2. Represents an attention model based on Sohlberg & Mateer’s 1987 model. This is a hierarchical model where the most basic type of attention, sustained, is at the bottom of the model, and the most difficult type of attention processing, divided, is at the top of the model.
evaluate attention performance after a TBI, with *Consonant Trigrams*, a test used to evaluate cognitive status after a TBI (Stuss, Ely, Hugenholtz, Richard, LaRochelle, Poirer, and Bell, 1985), in TBI patients who received APT. Even though all 23 participants improved their performance on both neuropsychological measures, the study had limitations. The study’s limitations included first that the control group received no training and second that there may have been a learning effect on the *PASAT* and *consonant trigrams* because they were administered successively to participants (Pero et al.).

In one of the first studies to investigate the efficacy of the *APT*, Sohlberg and Mateer (1987) treated four TBI participants with different etiologies, dates of injuries, and attention impairments using *APT*. All participants received five to 10 weeks of *APT* and showed significant gains in attention at the end of treatment. In fact, two of the participants with mild to moderate attention deficits scored within normal limits on the *PASAT* after *APT* (Sohlberg and Mateer). With exclusion of the Park et al. (1999) study, the studies in this section have demonstrated that *APT* improves attention processes.

As discussed earlier, the cognitive deficits demonstrated by individuals with TBI have also been demonstrated by individuals with PD. Although cognitive deficits in people with PD have been documented in the literature, there is no known literature to date describing treatment for any of those cognitive deficits. In her master’s thesis, Guillory (2011) examined the treatment efficacy of *APT* in with a single participant in an A1-B-A2-A3 multiple baseline study. She was unable to determine the treatment effect due to loss of post-treatment and follow-up probes. However, the participant reached criteria on sustained and selective attention tasks and showed improvement based on the
*APT-II Attention Questionnaire* (Sohlberg et al, 2001), a self-report measure. Additionally, Guillory (2011) reported that improved attention led to improved working memory performance on OSPAN and RSPAN working memory tasks. Though the study had limitations, it suggested that we might find a treatment effect for *APT* in individuals with PD if the study protocol was improved.

This study aimed to investigate whether attention processes can be improved using the *APT* protocol for an individual with PD and self-reported attention deficits. Despite differences in neuroanatomical etiology and recovery trajectory between TBI and PD, both TBI and PD patients exhibit similar attention impairments associated with frontal lobe dysfunction. Based on the literature reporting attention improvements in other populations with frontal lobe disorders after *APT* training, we hypothesized that this was a viable area of inquiry in the PD population. We asked the following experimental questions:

1. Is there a treatment effect for *APT* auditory stimuli in a person with PD after 6 weeks of treatment?
   
   We hypothesized that improvement would be demonstrated based on the literature that shows improvement in other populations with frontal lobe disorders like TBI.

2. Is there an improvement in the following secondary outcome measures of attention comparing baseline to post-treatment and one-month post-treatment?
   
   a. *Test of Everyday Attention (TEA)*
   
   b. *APT II Attention Questionnaire* (a self-report for attention control)
We hypothesized that improvement would be demonstrated on the *TEA* and the *APT II Attention Questionnaire*.

3. Is there an improvement in working memory following *APT* on OSPAN and RSPAN automated working memory tasks?

We hypothesized that improvement in working memory would be observed based on literature suggesting that attention is the foundation for working memory.

The results of this study, if positive, would provide preliminary evidence to support further research into: using *APT* to treat attention deficits in individuals with PD; training attention processes to improve working memory; and exploring the mechanisms by which attention is the foundation for higher-level cognitive processes.
CHAPTER 3. METHODS

3.1 Design

This phase I, multiple baseline A₁-B₁-A₂-A₃, single-subject study was conducted to determine whether APT showed a treatment effect for a participant with idiopathic PD and attention impairments. This was a phase I (pre-efficacy) study designed to explore and determine primary clinical outcome and/or therapeutic effect (Robey, 2004). The dependent variables of the study were the total number of errors (percent accuracy) on each attention task and the total number of minutes/seconds (timed performance) needed to complete each stimulus sheet. We selected auditory stimuli based on the participant’s reported attention deficits. We opted to use only auditory stimuli rather than using auditory and visuospatial stimuli because Guillory (2011) reported that criteria could not be reached on many of the visuospatial stimuli.

3.2 Participant

The Louisiana State University (LSU) Institutional Review Board for the protection of human subjects approved this study’s proposal prior to the enrollment of the participant and data collection. Informed consent was obtained from the participant prior to data collection. One 79-year old female participant presenting with idiopathic PD and self-reported attention deficits was recruited for this study from the Baton Rouge Parkinson’s Disease Support Group based on the following criteria:

1. diagnosis of PD by a neurologist,
2. no history or evidence of any other neurologic or neurodegenerative disease besides PD or language disorder,
3. a Mini Mental State Examination (Folstein, Folstein, & McHugh, 1975) score >24,
4. The Lillie Apathy Rating Scale (Sockeel, Dujardin, Devos, Deneve, Destee & Defebvre, 2006) rating \( \leq -16 \),
5. a Hoehn & Yahr Rating of Parkinson’s Disease (Hoehn and Yahr, 1967) 1-4,
6. a Geriatric Depression Scale (GDS) Short Form (Sheikh and Yesavage, 1986) score <10,
7. corrected visual acuity of 20/100 in the better eye determined by the Rosenbaum Pocket Vision Screener (Rosenbaum, 1982),
8. hearing within functional limits as determined by patient report and conversational analysis, and, lastly,
9. a self-reported concern about attention skills based on the APT-II Attention Questionnaire (Sohlberg et al, 2001).

Participants were excluded from the study if their scores were not above the cutoff for dementia, apathy, and/or depression (see cutoffs above). The participant’s characteristics are summarized in Table 1.

Table 1. Participant Characteristics

<table>
<thead>
<tr>
<th>CHARACTERISTICS</th>
<th>PARTICIPANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years Post-diagnosis</td>
<td>7</td>
</tr>
<tr>
<td>Hoehn &amp; Yahr Rating of Parkinson’s Disease (Hoehn and Yahr, 1967) ( \leq 1-4 )</td>
<td>2</td>
</tr>
<tr>
<td>The Lillie Apathy Rating Scale (Dujardin et al, 2006) ( \leq -16 )</td>
<td>-23</td>
</tr>
<tr>
<td>Mini Mental State Examination (Folstein et al, 1975) ( &gt;24 )</td>
<td>26</td>
</tr>
<tr>
<td>Geriatric Depression Scale (GDS) Short Form (Sheikh and Yesavage, 1986) ( &lt;10 )</td>
<td>1</td>
</tr>
<tr>
<td>Rosenbaum Pocket Vision Screener (Rosenbaum, 1982) 20/100</td>
<td>20/100</td>
</tr>
<tr>
<td>Hearing Screening</td>
<td>Passed</td>
</tr>
<tr>
<td>( APT-II ) Attention Questionnaire (Sohlberg et al, 2001) ( &gt;0 )</td>
<td>6</td>
</tr>
</tbody>
</table>
3.3 Outcome Measures

The following secondary outcome measures with established validity and reliability were taken at baseline, post-treatment, and follow-up: the Test of Everyday Attention (TEA) (Robertson, Ward, Ridgeway, & Nimmo-Smith, 1994), and the APT-II Attention Questionnaire (Sohlberg, Johnson, Paule, Raskin, & Mateer, 2001). To answer question three regarding changes in working memory, we chose to measure the OSPAN and RSPAN automated working memory tasks (Unsworth & Spillers, 2010).

The TEA is a valid and reliable attention battery that assesses attention processing deficits on functional tasks in adults with neurological injury, ranging in age from 18-80 years of age. The TEA includes eight subtests that measure four levels of attention: sustained attention, selective attention, attention switching, and auditory-verbal working memory. The TEA was used to identify target areas of attention impairments.

The APT-II Attention Questionnaire is a self-report to determine a participant’s perceived attention deficits (Sohlberg et al, 2001). To complete the report, the participant selected a statement that best described her attention deficits in 12 activities of daily living (ADLs). The questionnaire also provided a section for the participant to list five problematic events of attention impairments and describe her reactions to these events.

To assess working memory capacity, operation and reading span tasks were given to participant (Unsworth & Spillers, 2010). Operation span (OSPAN) tasks presented on a computer required the participant to solve a series of mathematical calculations (2+1, 9-1, etc.) while trying to remember a set of unrelated letters (F, H, J, K, L, N, P, Q, R, S, T, Y). The participant solved mathematical operation series. After solving the series, she was presented with a letter for one second. Immediately after the letter was presented, the
next mathematical operation was presented. The participant was asked to recall letters from the current series in the correct order by clicking on the appropriate letters. The participant received three practice sets. Items were scored if the mathematical calculation was correct and in the correct order (Unsworth & Spillers, 2010). Reading span (RSPAN) tasks required the participant to read sentences while trying to remember the same set of letters in the OSPAN tasks. The participant was asked to read a sentence and determine whether a sentence was logical while concurrently attempting to remember a set of unrelated letters (e.g. “The prosecutor’s dish was lost because it was not based on fact.”). After determining if the sentence was logical, the participant was presented with a letter series for one second. Then, the participant had to recall the set of unrelated letters in the correct order. Each task consisted of three sets of each set-size, ranging from three to seven, for a total of 75 letters and 75 sentence problems. The participant was instructed to maintain an accuracy level of 85% consistently throughout tasks. OSPAN and RSPAN were designed to examine the participant’s ability to store information while completing additional tasks. Absolute scores and total correct scores obtained from (OSPA) and reading (RSPAN) span tasks were used to analyze changes in working memory (Unsworth & Spillers, 2010).

3.4 Procedures

We conducted all phases of the study in the LSU Speech, Language, and Hearing Clinic. The investigator administered the treatment. A certified CCC-SLP with 25 years of experience treating adults with neurogenic communicative disorders trained and supervised her. Assessment and treatments were completed in a quiet therapy room to minimize distractions. All assessments and treatments were audio and video taped for
later reliability testing. To ensure treatment fidelity, the CCC-SLP supervisor reviewed one treatment session every-other week and addressed a drift from the protocol during post-treatment meetings. See study phases in Table 2.

Table 2. Represents A₁-B-A₂-A₃ single subject design used in this study

<table>
<thead>
<tr>
<th>STUDY ORDER</th>
<th>PHASE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A₁</td>
<td>Baseline phase</td>
</tr>
<tr>
<td></td>
<td>(Administration of primary and secondary outcome measures; collect baseline measures)</td>
</tr>
<tr>
<td>B</td>
<td>Treatment phase</td>
</tr>
<tr>
<td></td>
<td>(Intensity: 120 minutes; Frequency: 6 sessions; Duration: 6 weeks Total = 12 hours of treatment)</td>
</tr>
<tr>
<td>A₂</td>
<td>Post-treatment testing phase</td>
</tr>
<tr>
<td></td>
<td>(Administration of primary and secondary outcome measures will be completed immediately after completion of treatment)</td>
</tr>
<tr>
<td>A₃</td>
<td>One-month follow-up testing phase</td>
</tr>
<tr>
<td></td>
<td>(Administration of primary and secondary measures will be completed four weeks upon completion of treatment)</td>
</tr>
</tbody>
</table>

The primary and secondary outcome measures described above were administered to the participant in the baseline phase (A₁). Baseline data were collected until a stable baseline was established (approximately 3 sessions). Data included percent accuracy on attention task(s) and task completion in time, minutes, and seconds to complete task(s). The participant completed 120 minutes of therapy, once a week for 6 weeks, for a total of 6 treatment sessions and 12 hours of treatment over 6 weeks. Treatment was elicited in 30-45 minute intervals with 5-minute breaks in between to prevent fatigue. The investigator randomized and counterbalanced the probes for all phases of the study. She collected probe data at the end of each treatment session. On the next scheduled day after treatment (B) ended, she conducted the post-treatment testing phase (A₂) by collecting treatment probes and re-administering the secondary outcome measures. The participant
returned for follow-up testing (A₃) after completion of A₂. All of the same probes and secondary outcome measures administered at baseline (A₀) and post-treatment (A₂) were re-administered.

3.5 Treatment Protocol

We followed Sohlberg and Mateer’s (2005) APT hierarchical treatment protocol. Training was provided for the participant for each task using samples of questions and directions to confirm task comprehension. Tasks were repeated until an accuracy level of 85% was achieved over three consecutive presentations and/or a minimum 35% decrease in time was obtained over three consecutive presentations. Task difficulty increased once criterion level was achieved. If the participant did not reach criteria after 15 consecutive presentations, the task was abandoned, and task difficulty continued to increase. The participant completed each task according to the instructions received from the clinician. Responses obtained from the participant were collected and scored during each session according to the APT protocol manual to determine if the participant could move on to the next task. For a complete list of tasks, see Appendix C.

3.6 Reliability

The clinician established intra-rater reliability by re-analyzing the data collected from three randomly selected treatment activities from video and audio recordings. The clinician established inter-rater reliability by having a research volunteer simultaneously collect data through a live video feed during three randomly selected treatment sessions.

3.7 Data Analysis

Single-subject design studies typically use two established methods to determine treatment effect, visual analysis and one statistical analysis (Olive & Smith, 2005). To
answer question 1, we asked three judges who had no knowledge of the study to visually inspect the graphed data and decide whether or not performance had improved from A₁ (baseline) to A₂ (post-treatment), and A₃ (treatment withdrawal/follow-up) (McReynolds & Kearns, 1983; Kearns, 2000).

For statistical analysis, we chose to calculate effect size according to the Busk and Serlin (1992) method also described as the *standard mean difference* (SMD) effect size calculation (Busk & Serlin, 1992; Olive & Smith, 2005; Beeson & Robey, 2006):

\[ d = \frac{M_{A₂} - M_{A₁}}{SD_{A₁}} \]

where: \( d \) is effect size

- \( M_{A₂} \) is the mean of the post-treatment probes
- \( M_{A₁} \) is the mean of the baseline probes; and
- \( SD_{A₁} \) is the standard deviation of the baseline probes.

According to the literature the benefit of calculating SMD is that it results in a \( d \) statistic, which allows the researcher to use Cohen’s \( d \) effect size interpretation (i.e., 0.2 represents small effect, 0.5 represents moderate effect, 0.8 represents large effect) (Cohen, 1988) if no specific effect size interpretations exist (Olive & Smith, 2005; Beeson & Robey, 2006). Because this is a new area of inquiry and no effect size interpretations do exist, Cohen’s \( d \) interpretations were used. Effect sizes were calculated for each of the multiple baseline attention variables from baseline phase (A₁) to post-treatment phase (A₂), baseline phase (A₁) to one-month follow-up phase (A₃), and post-treatment phase (A₂) to one-month follow-up phase (A₃). Comparisons among secondary outcome measures were analyzed descriptively.
CHAPTER 4: RESULTS

By the end of treatment, the participant had attained criteria for eight of the CD series A increasingly complex sustained attention tasks during the treatment period out of 10 sustained attention tasks. We did not treat selective, alternating, or divided attention. See Appendix D for raw data of all treatment tasks.

4.1 Reliability

Intra-rater reliability was established by the clinician by reanalyzing data collected from three randomly selected treatment activities within three treatment sessions for average percent correct responses through video and audio recordings (see Table 3).

Table 3. Intra-rater reliability

<table>
<thead>
<tr>
<th>SESSION</th>
<th>TASKS</th>
<th>ACTUAL SCORE</th>
<th>REVIEWED SCORE</th>
<th>PERCENT AGREEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tx2</td>
<td>Attention CD Task IIA Fast</td>
<td>95%</td>
<td>95%</td>
<td>100%</td>
</tr>
<tr>
<td>Tx4</td>
<td>Attention CD Task IVA Slow</td>
<td>25%</td>
<td>25%</td>
<td>100%</td>
</tr>
<tr>
<td>Tx5</td>
<td>Attention CD Task IVA Slow</td>
<td>65%</td>
<td>65%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Inter-rater reliability was established with the use of a research assistant, whom simultaneously collected data for an average percent correct with the clinician during one randomly selected task within 3 treatment sessions (See Table 4).
Table 4. Inter-rater reliability

<table>
<thead>
<tr>
<th>TASKS</th>
<th>ACTUAL SCORE</th>
<th>REVIEWED SCORE</th>
<th>PERCENT AGREEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Session Tx2</strong></td>
<td>Attention CD Task IIA</td>
<td>80%</td>
<td>80%</td>
</tr>
<tr>
<td>Slow</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Session Tx4</strong></td>
<td>Attention CD Task IIIA</td>
<td>75%</td>
<td>75%</td>
</tr>
<tr>
<td>Fast</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Session Tx5</strong></td>
<td>Attention CD Task IVA</td>
<td>65%</td>
<td>65%</td>
</tr>
<tr>
<td>Slow</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.2 Question 1
In question 1 we asked, “Is there a treatment effect for APT auditory stimuli in a person with PD after 6 weeks of treatment?” We analyzed the probe data for sustained attention training using effect size calculations and visual analyses. First, the participant demonstrated a very large effect (.8 ≥) for sustained attention for percent accuracy (A₁ to A₂: \( d = 5.196 \); A₁ to A₃: \( d = 13.279 \); A₂ to A₃: \( d = 1.443 \)) and timed performance (A₁ to A₂: \( d = 2.952 \); A₁ to A₃: \( d = 3.153 \); A₂ to A₃: \( d = 0.287 \)). See Tables 5 and 6.

Table 5. Cohen’s d effect size for Percent Accuracy

<table>
<thead>
<tr>
<th>PERCENT ACCURACY</th>
<th>( d ) A₁ to A₂</th>
<th>( d ) A₁ to A₃</th>
<th>( d ) A₂ to A₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustained Attention</td>
<td>5.196*</td>
<td>13.279*</td>
<td>1.443*</td>
</tr>
<tr>
<td>Selective Attention</td>
<td>0.091</td>
<td>2.817*</td>
<td>1.299*</td>
</tr>
<tr>
<td>Alternating Attention</td>
<td>0.194</td>
<td>0.354</td>
<td>0.289</td>
</tr>
<tr>
<td>Divided Attention</td>
<td>1.225*</td>
<td>1.225*</td>
<td>2.860*</td>
</tr>
</tbody>
</table>

*Denotes large treatment effect
Table 6. Cohen’s d effect size for Timed Performance

<table>
<thead>
<tr>
<th>TIME</th>
<th>d A1 TO A2</th>
<th>d A1 TO A3</th>
<th>d A2 TO A3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustained Attention</td>
<td>2.952*</td>
<td>3.153*</td>
<td>0.287</td>
</tr>
<tr>
<td>Selective Attention</td>
<td>0.690</td>
<td>1.044*</td>
<td>1.598*</td>
</tr>
<tr>
<td>Alternating Attention</td>
<td>0.587</td>
<td>0.083</td>
<td>1.159*</td>
</tr>
<tr>
<td>Divided Attention</td>
<td>2.041*</td>
<td>1.225*</td>
<td>1.155*</td>
</tr>
</tbody>
</table>

*Denotes large treatment effect

The graphs depicted in Figures 3 (percent accuracy) and 4 (timed performance) were used to perform visual analysis. The three judges who visually inspected the graphs depicted in Figures 3 and 4 agreed that progress had been made for each A phase comparisons of sustained attention.

During visual inspection, the investigator observed that although sustained attention had been treated, changes appeared to be occurring in some of the probed attention areas that were not treated (selective, alternating, and divided attention). Therefore these three areas were analyzed to determine how performance had changed during sustained treatment training.

**Selective Attention:** The participant demonstrated a small effect ($\leq .2$) for percent accuracy of selective attention from the $A_1$ phase to $A_2$ phase ($d=.091$). However, there was a large effect ($.8 \geq$) for selective attention in the $A_1$ phase to $A_3$ ($d=2.817$) phase comparison and $A_2$ phase to $A_3$ comparison ($d=1.299$). See Table 5. Visual inspection by the three judges confirmed that there was no effect for percent accuracy for selective
attention with the A\textsubscript{1} phase to A\textsubscript{2} phase comparison. However, they also agreed that there was an effect from the A\textsubscript{1} phase to A\textsubscript{3} phase. See Figure 3. Contrarily, the participant demonstrated a medium effect for timed performance during the A\textsubscript{1} phase to A\textsubscript{2} phase ($d=0.690$). This medium effect confirmed that the participant’s timed performance improved although percent accuracy did not. Furthermore, the participant showed a large effect for timed performance during the A\textsubscript{1} phase to A\textsubscript{3} phase ($d=1.044$) and the A\textsubscript{2} phase to A\textsubscript{3} phase ($d=1.598$). See Table 6. In addition, visual analysis of selective attention timed performance graphs revealed there a treatment effect for all comparisons. See Figure 4.

*Alternating Attention* - A small effect ($\leq 0.2$) was established for percent accuracy of alternating attention for all phase comparisons (A\textsubscript{1} to A\textsubscript{2}: $d=0.194$; A\textsubscript{1} to A\textsubscript{3}: $d=0.354$; A\textsubscript{2} to A\textsubscript{3}: $d=0.289$). See Table 5. However, a medium effect was revealed for timed performance during the A\textsubscript{1} phase to A\textsubscript{2} phase ($d=0.587$), a small effect during the A\textsubscript{1} phase to A\textsubscript{3} phase ($d=0.083$), and a large effect during the A\textsubscript{2} phase to A\textsubscript{3} phase ($d=1.159$) comparisons. See Table 6. Visual analysis of alternating attention revealed no treatment effect for percent accuracy and timed performance. See Figures 3 and 4.

*Divided Attention* - The participant demonstrated a significantly large treatment effect for percent accuracy (A\textsubscript{1} to A\textsubscript{2}: $d=1.225$; A\textsubscript{1} to A\textsubscript{3}: $d=1.225$; A\textsubscript{2} to A\textsubscript{3}: $d=2.860$) and timed performance (A\textsubscript{1} to A\textsubscript{2}: $d=2.041$; A\textsubscript{1} to A\textsubscript{3}: $d=1.225$; A\textsubscript{2} to A\textsubscript{3}: $d=1.155$) for divided attention. See Tables 5 and 6. Visual inspection of divided attention graphs revealed a treatment effect for percent accuracy and timed performance See Figures 3 and 4.
Figure 3. Percent Accuracy on APT tasks showing multiple baseline structure of the study where sustained attention is trained and other attention processes are probed.
Figure 4. Time (in minutes and seconds) on APT tasks showing multiple baseline structure of the study where sustained attention is trained and other attention processes are probed.
4.3 Question 2

In question 2 we asked, “Is there an improvement in the following secondary outcome measures of attention comparing baseline to post-treatment and one-month follow-up? A) TEA and b) The APT II Attention Questionnaire”.

**TEA**

Figure 6 shows the scaled score comparisons of TEA subtests at baseline (A₁), post-treatment (A₂), and one-month follow-up (A₃). Scaled scores have a mean of 10 and a standard deviation of ±3. Analysis of the test results follow.

![TEST OF EVERYDAY ATTENTION](image)

Figure 5. TEA baseline, post-treatment, and one-month follow-up scaled scores.

The Lottery (L) and Elevator Counting (EC) subtests analyze changes in sustained attention. These subtests measure an individual’s ability to focus attention on a relatively unchanging task. Scaled scores from the Lottery (L) subtest at baseline (A₁), post-treatment (A₂), and one-month follow-up were A₁=2, A₂=2, and A₃=3. Scaled scores on
*Elevator Counting* (EC) subtest at baseline (A₁), post-treatment (A₂), and one-month follow-up were A₁=7, A₂=6, and A₃=6. The EC score at A₁ revealed 7 of 7 correctly counted strings of elevator beeps categorizing the participant in the normal range. During A₂ and A₃, the scores of EC revealed 6 out 7 correctly counted strings of elevator beeps, resulting in the “possibly abnormal” range. However, the normative sample obtained one error on the EC subtest, which means that a score of 6 does not necessarily mean there is an abnormality. Results of the *TEA* indicated maintenance in scaled scores subtests targeting sustained attention.

The *Map Search* (MS1 and MS2) and *Telephone Search* (TS) subtests analyze changes in selective attention. These subtests measure an individual’s ability to select important information while ignoring irrelevant information. Scaled scores from the one-minute MS1 subtest at baseline (A₁), post-treatment (A₂), and one-month follow-up were A₁=9, A₂=8, and A₃=9. Scaled scores on the two-minute MS2 subtest at baseline (A₁), post-treatment (A₂), and one-month follow-up were A₁=7, A₂=6, and A₃=8. Scaled scores on the TS subtest at baseline (A₁), post-treatment (A₂), and one-month follow-up were A₁=6, A₂=7, and A₃=7. As seen from the results, none of these comparisons showed a change in selective attention skills due the standard deviation.

The *Visual Elevator* (VEA) subtest will analyze changes in alternating attention. This subtest has two components: 1. *Visual Elevator* accuracy (VE1), 2. *Visual Elevator* timing (VE2). These components measure an individual’s ability to quickly alternate between two objects. This subtest consists two components, accuracy and timing, to measure the individual’s ability to alternate between two tasks. Scaled scores on the VE1 subtest at baseline (A₁), post-treatment (A₂), and one-month follow-up were A₁=2, A₂=2,
and $A_3=4$. Scaled scores on the VE2 subtest at baseline ($A_1$), post-treatment ($A_2$), and one-month follow-up were $A_1=0$, $A_2=0$, and $A_3=0$. The low scores on these tasks predicted to be caused by the visual-spatial deficits present in individuals with PD. We believe the major visual component of counting arrows in this task significantly affected the subject’s performance on VE1 and VE2. Again, none of these comparisons showed a change in selective attention skills due the standard deviation of the scores.

The *Telephone Search While Counting* (TSC) subtest will analyze changes in divided attention. This subtest will measure an individual’s ability to complete two tasks simultaneously. Scaled scores on the TSC subtest at baseline ($A_1$), post-treatment ($A_2$), and one-month follow-up were $A_1=0$, $A_2=6$, and $A_3=7$. The results of the TSC subtest indicated an improvement in divided attention.

The *Elevator Counting with Distraction* (ECD) and *Elevator Counting with Reversal* (ECR) subtests will analyze changes in auditory-verbal working memory. These subtests measure an individual’s ability to manipulate information in auditory-verbal working memory. Scaled scores on the ECD subtest at baseline ($A_1$), post-treatment ($A_2$), and one-month follow-up were $A_1=12$, $A_2=3$, and $A_3=8$. Scaled scores on the ECR subtest at baseline ($A_1$), post-treatment ($A_2$), and one-month follow-up were $A_1=7$, $A_2=7$, and $A_3=7$. Scaled score comparisons of the ECD subtest demonstrated a decline, contrarily, the ECR subtest showed maintenance for auditory-verbal working memory.

Overall, results comparing $A_1$ to $A_2$ and $A_3$ showed significant improvement for the *Telephone Search While Counting* (TSC). This subtest targeted divided attention. Furthermore, the following subtests indicated certain attention skills that were maintained: *Map Search* (MS1 and MS2), *Telephone Search* (TS), *Visual Elevator*
accuracy (VE1), Visual Elevator timing (VE2), Elevator Counting with Distraction (ECD). These subtests targeted the following levels of attention: sustained, selective, alternating, as well as auditory-working memory. However, the scores were not maintained for Elevator Counting with Reversal (ECR), which targeted alternating attention and auditory-verbal working memory. In summary, the results of the TEA indicated an improvement or maintenance in the scaled scores of each subtest.

**APT II Attention Questionnaire**

At baseline (A1), the participant scored a 6 on the subjective attention control rating, indicating decreased attention had a little-to-mild disruptive effect on the subject’s quality of life. At post-treatment (A2), the participant scored a 20, indicating that decreased attention had a moderate disruption on the participant’s quality of life. At one-month follow-up, the participant scored a 19, indicating decreased attention had a moderate disruption on the participant’s life. Reasons for this noted decline despite improved attention scores on specific tasks will be discussed in the next section.

**4.4 Question 3**

In question 3 we asked, “Is there an improvement in working memory as measured by the OSPAN and RSPAN automated working memory tasks following APT?”.

Five values were reported upon completion of each task: OSPAN and RSPAN absolute score (sum of all perfectly recalled sets), total correct (total number of letters recalled accurately), math or reading errors (total number of errors made), speed errors (errors due to the participant running out of time), and accuracy errors (errors in which the participant inaccurately solved the math problem or verified the sentence). Raw
scores obtained from the OSPAN and RSPAN span tasks were used to analyze maintenance of the treatment effect immediately post treatment and one-month following completion of the APT protocol. A summary of OSPAN and RSPAN absolute and raw scores are in figures 6 and 7.

Figure 6. Summary of OSPAN absolute score (sum of all perfectly recalled sets), total correct (total number of letters recalled accurately), math or reading errors (total number of errors made), speed errors (errors due to the participant running out of time), and accuracy errors (errors in which the participant inaccurately solved the math problem or verified the sentence).

Figure 7. Summary of RSPAN absolute score (sum of all perfectly recalled sets), total correct (total number of letters recalled accurately), math or reading errors (total number of errors made), speed errors (errors due to the participant running out of time), and accuracy errors (errors in which the participant inaccurately solved the math problem or verified the sentence).
Scores on the OSPAN tasks indicate improved in performance for absolute scores, accuracy errors, speed errors, and math errors. The total correct letters recalled was the only area in which more errors were observed during one-month follow-up. Scores on the RSPAN tasks indicated an increase or maintenance in performance in all areas of the RSPAN tasks. In summary, an increase in performance was observed in the following scores: OSPAN absolute scores, OSPAN accuracy errors, OSPAN math errors, RSPAN speed errors, RSPAN math errors, and RSPAN total correct.
CHAPTER 5: DISCUSSION

We designed this investigation as a phase I, multiple baseline $A_1$-$B$-$A_2$-$A_3$, single-subject study to determine the primary clinical outcome and/or therapeutic effect (Robey, 2004) of $APT$ training for an individual with PD and attention deficits. We demonstrated a treatment effect for sustained attention when $APT$ training was administered to an individual with PD two hours per session, one time a week, for six weeks. Moreover, although untrained, the treatment effect of sustained attention generalized to selective and divided attention, more complex tasks. However, this improvement was not reflected on the secondary outcome measures we chose, the $TEA$ and $APT$ II Attention Questionnaire. The $APT$ training appears to have led to changes in the participant’s ability to perform working memory tasks more quickly. However those changes were not consistently reflected in the absolute scores and the total correct for reading span tasks. We believe the changes in working memory were not consistently observed in either OSPAN or RSPAN tasks because individuals with PD have difficulty recalling word lists and sequencing words (Nieoullon, 2002; Dubois et al., 1994; Kane & Engle, 2002). The implication of these results will be discussed in the following sections, followed by the study’s limitations and direction for future research.

5.1 Question 1

The purpose of experimental question 1 was to determine if there was treatment effect for the $APT$ auditory stimuli in a person with PD after 6 weeks of treatment. The results demonstrated that the participant improved after receiving sustained attention training. Increased performance generalized to untrained selective and divided attention probes as well. As mentioned earlier, the $APT$ was administered at a more intense level (2
hours per session rather than 1 hour per session) than has been reported in the literature, to meet the participant’s schedule. Alternating attention probes did not improve. Our results differ from Guillory’s (2011) study that reported little generalization to more complex attention processes in a single participant with PD and attention deficits. Obviously, the difference in results could stem from the difference in participants. However, another possible explanation for our results is that the increased treatment intensity may have contributed to the generalization effects noted.

Because the participant made improvement on divided attention probes, but not alternating attention probes, the obvious explanation is that the most difficult task for alternating attention in the *APT* was more difficult than the most difficult task for divided attention. Therefore, we reviewed the two probe tasks to better understand the results. On the alternating attention task, the participant had to remember a set of numbers and present them alternating between ascending and descending order. The task involved not only alternating between the ascending and descending order, but also holding the set of numbers in working memory. However, on the divided attention task, the participant had to monitor and report when 5-minutes had elapsed while completing a sustained attention task. We suggest that because the participant’s sustained attention improved significantly, the sustained portion of the divided attention task became easier (i.e., it did not demand much working memory capacity) and she was able to allocate more attention resources to monitoring time.

This hypothesis is consistent with Cowan’s (2005) work in modeling the focus of attention and working memory. In the Cowan model, an individual focuses attention on one task when competing stimuli is present. At the start of *APT*, we speculate that
performance on the divided attention probe (time monitoring and cancellation task), the participant focused on the cancellation task to the extent that she failed to attend to the time monitoring task. As she improved on the sustained attention portion of the divided attention task, she was able to shift working memory focus to time monitoring more accurately and more efficiently. However, during the alternating attention task, the participant had to expand the focus of her attention to hold a set of numbers in working memory while she alternately reported them in ascending and descending order. According to Cowan, the expanded focus of attention inhibits the intensity and precision of attention and working memory processes and results can result in decreased accuracy and efficiency.

After considering Cowan’s model (2005), and reviewing the APT alternating and divided attention tasks, it seems that the tasks should be reversed. The divided attention task actually allowed the participant to focus closely on one task and then another (i.e. alternating attention), while the alternating attention task required the participant to hold information in working memory and perform different functions with the information (i.e. divided attention). In summary, while our results for question 1 indicate that training sustained attention tasks improved performance on selective and divided attention tasks for an individual with PD, we suggest that further study into the APT attention hierarchy and tasks.

5.2 Question 2

We designed question 2 to determine if the selected secondary outcome measures: TEA and the APT II Attention Questionnaire reflected changes that occurred during the treatment. Our hypothesis that an improvement in training specific tasks would be
demonstrated on functional attention activities was not confirmed. Our results for this one participant concur with Sohlberg et al. (2001) who reported that there are no definitive results to indicate that training generalizes to functional tasks in the TBI population. Closer inspection of the patient’s responses indicated improvement on some tasks. Performance on the TEA improved for most tasks when baseline was compared to post-treatment. However, when standard deviations were considered, the participant demonstrated no appreciable changes in performance across the three time periods. As noted in the results section, the participant reported more attention disruptions in the APT II Attention Questionnaire self-report measure at post-treatment and one-month follow-up than she did at baseline. The participant explained that treatment made her more aware that she had attention problems. She also reported that because of this increased awareness she was using techniques learned in treatment to compensate for her attention deficits. Her positive report, although anecdotal, suggests the need to investigate further the effect APT training has on self-awareness of attention deficits in people with PD.

5.3 Question 3

We designed question 3 to determine if there was improvement in working memory on OSPAN and RSPAN working memory tasks following APT. We noted improved OSPAN working memory total correct, absolute scores, speed errors, and math errors from baseline to post-treatment and follow-up. Speed errors and math errors improved for RSPAN tasks as well. OSPAN and RSPAN errors decreased at post-treatment and follow-up. However, these error changes in RSPAN were not reflected in the absolute and total correct scores used to interpret change in memory recall. An improvement in OSPAN working memory tasks was observed, which indicated a
relationship between attention and working memory with people with PD. A significant improvement was not observed for RSPAN working memory tasks. The probe tasks used in the study were all operational. Therefore, we believe the operational probes trained the participant, which explains her improvement for the OSPAN working memory tasks and not the RSPAN tasks. These findings suggest that training attention deficits may potentially lead to improvement in working memory.

5.4 Study Limitations

We found several limitations in this study that when corrected will help improve the next phase of research. First, results from a single-subject study are influenced by the participant’s session-to-session performance. For instance, the participant demonstrated a notable decline in performance during session P11. In retrospect, we discovered two differences that may have affected her performance: the appointment time was changed from morning to late afternoon; and belatedly, she reported that she had not taken her PD medication before coming to therapy. Second, this is a preliminary study using a single subject so results cannot be generalized. Third, we structured the APT very specifically to control for visuospatial spatial confounds noted in a previous study (Guillory, 2009). Therefore, our results do not apply to the entire APT protocol.

5.5 Future Research

Now that we have a stable protocol that has demonstrated positive results, future research could include replicating this study with more participants with PD. Additionally, including more participants might show concrete improvements for working memory and validate whether attention is a foundation for working memory. Alternatively, future research might include analyzing the APT tasks to see how they
conform to Cowan’s (2005) model of attention, based on our observations regarding the discrepancy in task difficulty between alternating and divided attention tasks. From there, a new pilot study could be developed to determine the treatment effect of a revised APT protocol. We modified the APT protocol because Guillory (2009) reported that it included a combination of auditory and visuospatial tasks throughout that affected her participant’s performance. A future study might investigate the treatment effect of APT using only the visuospatial tasks, since visuospatial deficits have been reported in individuals with PD.

5.6 Conclusion

In summary, the results suggest that APT delivered at a high intensity of two hours per session may benefit individuals with PD that present with attention deficits at a high intensity of two hours per session. The treatment effect found for sustained attention (the most basic attention level), carried over to selective and divided attention as well. We suggest that perhaps the divided attention tasks were not as difficult as the alternating tasks, and that perhaps the traditional attention hierarchy may not make sense for the PD population. Research continues to demonstrate that people with PD have cognitive deficits including attention deficits even early in the disease process (Murdoch & Whelan, 2009). Therefore, it is crucial that speech-language pathologists recognize those cognitive deficits as well as speech problems of the PD population, and seek to find evidence-based treatments to address them.
REFERENCES


<table>
<thead>
<tr>
<th><strong>TEA subtest</strong></th>
<th><strong>Description</strong></th>
<th><strong>Area of attention targeted</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevator Counting</td>
<td>An auditory task that requires the subject to complete simple counting procedures (counting seven strings of tones).</td>
<td>Sustained attention</td>
</tr>
<tr>
<td>Lottery</td>
<td>An auditory task requiring the subject to listen to a string of letters and numbers (e.g. BC143) and specify the two letters preceding all numbers in “55.”</td>
<td>Sustained attention</td>
</tr>
<tr>
<td>Map Search</td>
<td>A visual search task involving searching a map for two minutes and circling a specified symbol when located.</td>
<td>Selective attention</td>
</tr>
<tr>
<td>Telephone Search</td>
<td>A visual task in which the subject is required to search a telephone directory for a specified group of symbols.</td>
<td>Selective attention</td>
</tr>
<tr>
<td>Visual Elevator</td>
<td>A visual task requiring the subject to count elevator doors imagining it as a representation of a floor, following the arrows signifying the elevator is moving up or down.</td>
<td>Alternating attention</td>
</tr>
<tr>
<td>Telephone Search while Counting</td>
<td>A visual task in which the subject is required to search a telephone directory for a specified group of symbols while simultaneously counting the number of tones presented auditorily.</td>
<td>Divided attention</td>
</tr>
<tr>
<td>Elevator Counting with Distraction</td>
<td>An auditory task that requires the subject to complete simple counting procedures while not counting a distracting tone.</td>
<td>Auditory-verbal working memory</td>
</tr>
<tr>
<td>Elevator Counting with Reversal</td>
<td>An auditory task requiring the subject to count floors as signified by a higher-pitched tone to designate going up and a lower-pitched tone to designate going down.</td>
<td>Auditory-verbal working memory</td>
</tr>
</tbody>
</table>
APPENDIX B: *APT-II ATTENTION QUESTIONNAIRE*  
(Sohlberg, Johnson, Paule, Raskin, & Mateer, 2001)  
(Authors permitted reproduction.)

Client Name: ________________________________________________  
Rater’s name and relationship to client (if applicable): ________________________________  
Therapist: ___________________________ Date: ____________________________

I. **RATING SCALE:** Please answer the following questions about your attention as it applies to daily function by checking the box that offers the best description.

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>Not a problem or no change from before</th>
<th>Only gets in the way on occasion (less than once a week)</th>
<th>Sometimes gets in the way (about 1-3 times per week)</th>
<th>Frequently gets in the way (is a problem most days)</th>
<th>Is a problem all the time (affects most activities)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I seem to lack mental energy to do activities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. I am slow to respond when asked a question or when participating in conversations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. I can’t keep my mind on activity or thought because my mind keeps wandering</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. I can’t keep my mind on activity or thought because my mind feels “spacy” or “blank”</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. I can only concentrate for very short periods of time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. I miss details or make mistakes because of level of concentration decreased</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### II. INDIVIDUALIZED ATTENTIONAL PROBLEM LIST

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

<table>
<thead>
<tr>
<th>Describe Attention Breakdown (include setting and approx. frequency)</th>
<th>What do you do when your attention breakdown occurs?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example: I cannot concentrate when I am preparing dinner because the noise from the children playing around my feet and even in the next room distracts me. I forget ingredients or parts of the meal and usually feel totally frustrated during this time. This happens for every dinner.</td>
<td>Example: I often yell or blow up at the children or cry while I am cooking. Sometimes I just give up and make something simple like sandwiches.</td>
</tr>
<tr>
<td>7. I easily get off track if other people are milling about nearby</td>
<td></td>
</tr>
<tr>
<td>8. I am easily distracted by surrounding noise</td>
<td></td>
</tr>
<tr>
<td>9. I have trouble paying attention to conversation, if there is more than one other person</td>
<td></td>
</tr>
<tr>
<td>10. I easily lose my place if task or thinking is interrupted</td>
<td></td>
</tr>
<tr>
<td>11. I am easily overwhelmed if task has several components</td>
<td></td>
</tr>
<tr>
<td>12. It is difficult to pay attention to more than one thing at a time</td>
<td></td>
</tr>
</tbody>
</table>
**APT-II ATTENTION QUESTIONNAIRE SCORING**

Scoring:

a) Total number of items checked in second column multiplied by (1)_____

b) Total number of items checked in third column multiplied by (2)_____

c) Total number of items checked in fourth column multiplied by (3)_____

d) Total number of items checked in fifth column multiplied by (4)_____

Total Score: Add a) through d)_____

<table>
<thead>
<tr>
<th>Score Obtained</th>
<th>Level of Disruption on ADLs</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-12</td>
<td>Little – Mild disruption</td>
</tr>
<tr>
<td>13-24</td>
<td>Moderate disruption</td>
</tr>
<tr>
<td>25-36</td>
<td>Severe disruption</td>
</tr>
<tr>
<td>37-48</td>
<td>Profound disruption</td>
</tr>
</tbody>
</table>
APPENDIX C: TARGETED APT TASKS

SUSTAINED ATTENTION TASKS
- Attention CD Tasks (Series A, B, & C)
- Paragraph Listening Task
- Alphabetized Sentence Task
- Reverse Sentence Task
- Progressive Sentence Task
- Number Sequencing Ascending Task
- Number Sequencing Descending Task
- Number Sequence Reverse Task
- Number Sequence Every Other Task
- Mental Math Activity

SELECTIVE ATTENTION ACTIVITIES
- Attention CD Tasks (Series E, F, & G)
- Sustained Attention Task with Distractor Noise
- Sustained Attention Task with Distractor Movement

ALTERNATING ATTENTION TASKS
- Attention CD Tasks (Series E, F, & G)
- Serial Numbers Task
- Sentence Change Task
- Number Change Task

DIVIDED ATTENTION ACTIVITIES
- Attention CDs with Simultaneous Task
- Time Monitoring Task
APPENDIX D: RAW DATA FOR ATTENTION TASKS

RAW DATA SESSION 1

RAW DATA SESSION 2

RAW DATA SESSION 3
APPENDIX E: INSTITUTIONAL REVIEW BOARD APPROVAL

Project Report and Continuation Application

(Complete and return to IRB, 131 David Boyd Hall, Direct questions to IRB Chairman Robert Mathews 579-8692.)

IRB#: 3125  Current Approval Expires On: 8/17/2012

Review Type: Expedited  Risk Factor: Minimal

PI: Neila Dotovan  Dept: COMD  Phone: 6-3838

Student/Co-Investigator: **Kristen Ferguson

Project Title: Treatment effects of Attention Process Training for an individual with idiopathic Parkinson's disease.

Number of Subjects Authorized: N/A  New MA student completing thesis Requesting continuation of this study to replicate it with a different subject.

Please read the entire application. Missing information will delay approval.


I. PROJECT FUNDED BY: N/A

LSU Proposal #: N/A

II. PROJECT STATUS: Check the appropriate blank(s) and complete the following:

- 1. Active, subject enrollment continuing # subjects enrolled: **See above note, requesting continuation to replicate study, no changes in the protocol.

- 2. Active, subject enrollment complete: # subjects enrolled: 

- 3. Active, subject enrollment complete: work with subject continues.

- 4. Active, work with subjects complete: data analysis in progress.

- 5. Project start postponed

- 6. Project cancelled: no human subjects used.

- 7. Project complete: end date

III. PROTOCOL: (Check one).

- Protocol continues as previously approved

- Changes are requested

- List on separate sheet any changes to approved protocol.

IV. UNEXPECTED PROBLEMS: (Did anything occur that increased risks to participants):

- State number of events since study inception: 0 since last report: 0

- If such events occurred, describe them and how they affect risks in your study, in an attached report N/A

- Have there been any previously unreported events? Y/N NO

V. CONSENT FORM AND RISK/BENEFIT RATIO:

- Do new knowledge or adverse events change the risks/benefit ratio? Y/N NO

- Is a corresponding change in the consent form needed? Y/N NO

VI. ATTACH A BRIEF, FACTUAL SUMMARY of project progress/results to show continued participation of subjects is justified; or to provide a final report on project findings.

VII. ATTACH CURRENT CONSENT FORM (only if subject enrollment is continuing); and check the appropriate blank

- 1. Form is unchanged since last approved

- 2. Approval of revision requested herewith (identify changes)

Signature of Principle Investigator: [Signature] Date: 7/30/12

IRB Action: 

- Continuation approved
- Disapproved
- File Closed

Approval Expires: 7/30/13

Signed [Signature] Date: 7/31/12

Print Form
VITA

Kristen Michelle Ferguson, a native from Houston, TX, received her bachelor’s degree in Corporate Communications and Speech-Language Pathology from the University of Texas at Austin in 2010. Thereafter, she made the decision to enter graduate school in the Department of Communication Sciences and Disorders at Louisiana State University. She will receive her master’s degree in May 2013 and plans to begin working as a speech-language pathologist upon graduation.