EVALUATION OF DIRECT ATTENTION TRAINING AND METACOGNITIVE FACILITATION TO IMPROVE READING COMPREHENSION IN INDIVIDUALS WITH MILD APHASIA

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DISSERTATION ABSTRACT

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Title: Evaluation of Direct Attention Training and Metacognitive Facilitation to Improve Reading Comprehension in Individuals with Mild Aphasia

People with aphasia (PWA) frequently present with nonlinguistic deficits, in addition to their compromised language abilities, which may contribute to their problems with reading comprehension. Treatment of attention, working memory and executive control may elicit reading comprehension improvements in PWA, particularly those with mild reading problems.

This study evaluated the efficacy of Attention Process Training-3 (APT-3), an intervention combining direct attention training and metacognitive facilitation, for improving reading comprehension in individuals with mild aphasia and concomitant reading comprehension difficulties. A multiple-baseline design across six participants was used to evaluate treatment effects. The primary outcome measure was a maze reading task. Pre- and post-treatment evaluation included cognitive and reading measures. Semi-structured interviews were conducted to evaluate participant-perceived changes in cognition and reading.

Visual inspection of graphed maze reading performance data indicated a basic effect between APT-3 and improved maze reading for three of the six participants. Quantitative analyses, using Tau-U, corroborated findings identified through visual analysis. The results suggest that the use of APT-3 has the potential to improve reading in PWA but that it may be more efficacious under certain conditions. Treatment and participant variables, including intensity of treatment and metacognitive strategy usage, are discussed as potential influences on participants' responsiveness to APT-3.

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CHAPTER I

INTRODUCTION

Despite an estimated 100,000 new cases of aphasia per year in the United States (NAA, 2012; NIH Pub No. 08-4232, 2008) people with aphasia (PWA) represent an underserved population. Rehabilitation efforts have focused on patients in the acute stage of aphasia, often prioritizing dysphagia management over treatment for the communication disorder (Hallowell & Clark, 2002). Further, legislation and changes in managed care have resulted in increasing restrictions on the frequency and duration of reimbursable treatment for PWA requiring rehabilitation services (Henri & Hallowell, 1999; Katz et al., 2000). Recent evidence illustrates the importance of intensive therapy and repeated practice to induce neural plasticity (Kerr, Cheng, & Jones, 2011; Kleim, 2011; Kleim & Jones, 2008), and growing research from the aphasia literature indicates that more treatment is associated with better outcomes for PWA (Baker, 2012; Bhogal, Teasell, & Speechley, 2003; Cherney, Patterson, Raymer, Frymark, & Schooling, 2008; Robey, 1998). However, actual practice patterns indicate that PWA are routinely denied treatment and there is a widening gap between the efficacy literature and the reality of treatment delivery (Katz et al., 2000).

Reading problems are reported by the majority of individuals with chronic aphasia (Webb & Love, 1983). Yet, acquired reading impairment, or alexia, is often disregarded in individuals with aphasia, not only because of the limitations on reimbursable outpatient services, but because of the prioritization of spoken language deficits characteristic of aphasia. As Rosenbek and colleagues remark:

"Judging from the lack of literature and the relatively meager research effort afforded to the subject, at the prom of aphasia, reading impairment has achieved the popularity of a bird in the punch bowl" (Rosenbek, LaPointe, & Wertz, 1989, p. 163). The limited attention given to reading rehabilitation may also simply reflect limited knowledge of treatment approaches for acquired alexia in comparison to treatment of spoken language (Beeson & Henry, 2008).

Nonetheless, reading is important, and the consequences of reading impairment for PWA can be substantial. Reading difficulties present barriers for successful return to work or school (Graham, Pereira, & Teasell, 2011; Hinckley, 2002) and, paired with other communication impairments, have negative ramifications for life participation goals and life satisfaction (Sarno, 1997). Communication in the twenty first century is increasingly mediated by text (including email, instant messaging, texting, and social networking websites), which further exacerbates the difficulties individuals with aphasia and alexia have with maintaining social connectedness and reestablishing social roles. As face-to-face communication is replaced by automated machines and the internet becomes the primary vehicle for news, entertainment, shopping and managing finances, there are also increasing functional consequences of reading impairments (Beeson & Henry, 2008).

Treatment Gaps for Acquired Alexia

There is an abundance of information in the research literature on treatment of aphasia, but the vast majority of intervention addresses spoken language deficits of PWA. Again, there is relatively little treatment research dedicated to reading problems associated with aphasia (Beeson & Henry, 2008; Rosenbek et al., 1989). Reading impairments resulting from stroke are termed acquired alexia. A recent study documented alexia in approximately 80% of participants with aphasia (Wilson, 2008). Most of the reading intervention described in the aphasia literature is based on cognitive neuropsychological or psycholinguistic models of reading (e.g., Marshall & Newcombe, 1973; Perfetti, 1999). When applied to aphasia, these models specify the component processes of single word reading, namely the pre-linguistic visual system, the non-lexical-phonologic, the lexical-phonologic and the semantic systems (Ellis, 1993; Hillis & Caramazza, 1992). Diagnosing the acquired alexia syndrome involves isolating the point of disruption in the reading process, which may occur at the level of orthography, phonology, or semantics. Subsequently, treatment derived from a cognitive model of reading is typically designed to strengthen these points of breakdown in the lexical or non-lexical processing of written language (Beeson & Insalaco, 1998). For example, treatments designed to target the non-lexical route focus on strengthening or reestablishing letter-to-sound correspondence (e.g., DePartz, 1986; Mitchum & Berndt, 1991; Nickels, 1992). Treatment for disrupted lexical-semantic processes, on the other hand, may include written word to picture matching tasks that reinforce the relationship between word forms and their meanings (e.g., Hillis & Caramazza, 1991).

Numerous treatment studies provide evidence that reading can be improved for individuals with specified alexia syndromes (see review by Cherney, 2004). However, the majority of studies document improved single word reading or improved reading accuracy of a corpus of single words (Cherney, 2004) with little information on reading performance of connected text, which is often the ultimate goal of treatment (Beeson & Insalaco, 1998). It has also been argued that "these [treatment] efforts often are directed toward experimentally derived syndromes (i.e., deep dyslexia, phonological alexia) and the emphasis is on single-word reading and letter-by-letter processing rather than authentic reading." (Lynch, Damico, Damico, Tetnowski, & Tetnowski, 2009, p. 222).

The existing treatment protocols for alexia that target connected text reading, rather than single words, involve oral reading of sentences and paragraphs (Beeson & Insalaco, 1998; Cherney, 2010b; Cherney, Merbitz, & Grip, 1986). Improved reading comprehension, as well as improved comprehension and production of spoken language, in individuals with varying severities of aphasia have been reported following Oral Reading for Language in Aphasia (Cherney, 2010b; Cherney et al., 1986). Beeson and Insalaco (1998) reported increased reading rate of individuals who received the text-level treatment, Multiple Oral Reading; however, reading *comprehension* was not explicitly targeted, nor shown to improve. Taken together, the studies reported in the literature point to a gap in treatment for acquired alexia. Although positive results have been reported for various types of alexia, the protocols described to date fail to address the high-level reading comprehension problems experienced by many individuals with mild aphasia, particularly those with reading difficulties that do not align with a clearly specified alexia syndrome. For these PWA, improving reading comprehension may be a key determiner of meaningful rehabilitation outcomes, including return to work and improved life satisfaction.

Cognitive Impairment: A Contributing Factor

In addition to their compromised language abilities, PWA frequently present with nonlinguistic deficits, which may also contribute to their problems with reading comprehension. An established body of research indicates that PWA demonstrate cognitive difficulties that are independent of other linguistic impairments, including deficits in orienting attention (Robin & Rizzo, 1989), sustained attention (Gerritsen, Berg, Deelman, Visser-Keizer, & Jong, 2003; Korda & Douglas, 1997; Laures, 2005), divided attention (Erickson, Goldinger, & LaPointe, 1996; Murray, Holland, & Beeson, 1997b, 1997c, 1998), allocation of resources (LaPointe & Erickson, 1991; Murray et al., 1997b, 1997c, 1998) and working memory (Christensen & Wright, 2010). Furthermore, "cognitive difficulties that are independent of language-specific deficits have been implicated in both aphasic and nonaphasic individuals with reading disorders" (Mayer & Murray, 2002, p. 728). For example, Daneman and Carpenter (1980) demonstrated an association between working memory capacity and reading comprehension in healthy young adults. Caspari and colleagues (1998) documented a strong positive correlation between working memory capacity and reading comprehension in a group of individuals with aphasia. Although less widely studied, PWA demonstrate metacognitive impairments, such as self-monitoring of performance and effort during complex tasks (Clark & Robin, 1995; LaPointe & Erickson, 1991; Laures, Odell, & Coe, 2003;

Murray, Holland, & Beeson, 1997a), that also have the potential to influence successful reading comprehension.

Treatment of Cognitive Impairments

As previously described, intervention for acquired alexia has been predominantly driven by models depicting component processes understood to be necessary for comprehension with the aim of strengthening or reestablishing degraded or impaired processes. An alternative approach to treating alexia that is gaining interest in the aphasia literature is to address the cognitive deficits that underlie the linguistic components of the reading process. Treatment of attention, working memory and executive control may elicit reading comprehension improvements in PWA, particularly those with mild reading problems that do not align with specified alexia syndromes.

Research findings suggesting that non-linguistically based cognitive deficits can negatively impact language comprehension and production in PWA have led several researchers to explore direct attention training (DAT) as an aphasia intervention (e.g., Coelho, 2005; Helm-Estabrooks, Connor, & Albert, 2000; Murray, Keeton, & Karcher, 2006). DAT is based on the notion that attentional abilities can be improved by activating and stimulating the impaired attention system through repetitive drills, which promotes recovery of damaged neural circuits and improves attentional processing (Sohlberg & Mateer, 2001). While labeled "attention training," intervention programs that have been evaluated in the neurogenic literature target a broad range of attention, working memory and executive control processes (Butler et al., 2008; Duval, Coyette, & Seron, 2008; Sohlberg, 2000).

Preliminary evidence suggests that DAT can improve attentional processing in individuals with aphasia (Barker-Collo et al., 2009; Sturm & Willmes, 1991; Sturm, Willmes, Orgass, & Hartje, 1997). Initial research also suggests that improvements in attention resulting from DAT correspond to improved language skills in auditory comprehension (Helm-Estabrooks et al., 2000) and reading comprehension (Coelho, 2005; Mayer & Murray, 2002; Sinotte & Coelho, 2007).

Given findings that PWA demonstrate difficulty in self-monitoring performance and effort during complex tasks (Clark & Robin, 1995; LaPointe & Erickson, 1991; Laures et al., 2003; Murray et al., 1997a), it is possible that PWA could benefit from metacognitive instruction and feedback related to carrying out complex or demanding activities. When paired with attention training, metacognitive strategy instruction typically emphasizes facilitating efficient allocation of cognitive resources by providing feedback, goal setting and self-awareness enhancement (Sohlberg et al., 2003). Preliminary evidence suggests that DAT combined with metacognitive facilitation may elicit improvements in attentional resources, as well as the deliberate mobilization and allocation of resources necessary for successful reading comprehension (Lee & Sohlberg, 2013). The influence of metacognitive facilitation on language outcomes for PWA is still an emerging area of investigation. Recent research in the area of naming treatment, however, has identified feedback and the ability to monitor errors and modify behaviors on the basis of feedback as important variables (Fillingham, Hodgson, Sage, & Ralph, 2003; McKissock & Ward, 2007). Moreover, Lee and Sohlberg (2013) also suggest that feedback, i.e. reviewing performance, was crucial in helping participants with aphasia identify error patterns and deliberately allocate their attention on future challenging tasks.

Statement of Purpose

The purpose of this study was to examine the efficacy of the Attention Process Training-3 program (APT-3; Sohlberg & Mateer, 2010), an intervention combining DAT and metacognitive facilitation, for improving reading comprehension in individuals with mild chronic aphasia and concomitant reading comprehension difficulties. While studies have evaluated the efficacy of DAT for improving attention and related cognitive processes in individuals with traumatic brain injury (e.g., Sohlberg, 2000), attention training remains a relatively new area of investigation in the aphasia literature. This study sought to extend preliminary findings evaluating the impact of DAT on reading comprehension in PWA (e.g., Coelho, 2005; Sinotte & Coelho, 2007). APT-3 was selected as the experimental intervention because the program (a) contains a range of exercises that address sustained attention, working memory, and executive control, which have been found to be impaired in PWA and (b) promotes metacognition, specifically self-monitoring, through performance feedback and strategy instruction delivered as part of the attention training. A single subject, multiple-baseline design across participants was used to evaluate whether there is a functional relation between APT-3 and improvements in reading comprehension in individuals with aphasia and concomitant reading difficulties. This dissertation extends the literature on cognitively driven intervention for PWA and addresses the current gap in treatment for individuals with chronic aphasia and high-level reading comprehension deficits.

The next chapter begins by providing a characterization of reading impairments in PWA, namely the distinct alexia syndromes identified by the cognitive neuropsychological model of single word reading. This is followed by a description of the reading comprehension difficulties documented in individuals with mild aphasia. Next, an account of reading comprehension processes and the role of working memory is described. In the next section, research findings documenting cognitive impairments in PWA are reviewed, followed by a discussion of the resource allocation model of attention in aphasia. This is followed by a review of the attention treatment research conducted with PWA to address reading impairment. The chapter concludes with the research questions explored in the dissertation.

In Chapter III, the methods for the research study are detailed. This section includes a detailed description of the experimental intervention and measures used in the study. The experimental design, procedures, and analyses are also described. Chapter IV provides a summary of the results. Chapter V concludes the dissertation with a discussion of findings.

CHAPTER II

REVIEW OF THE LITERATURE

Reading Impairments Associated with Aphasia

Some degree of alexia, or reading impairment, is reported in the majority of people with chronic aphasia (Webb & Love, 1983). PWA present with a wide range of reading abilities, and there is not a predictable relationship between type of aphasia and the alexia profile for an individual with aphasia (Beeson & Insalaco, 1998). The most widely used model to describe reading deficits in PWA is the cognitive neuropsychological model developed for single word reading aloud, which facilitates identification of distinct alexia syndromes caused by breakdowns at different points in the reading process (Ellis, 1993; Hillis & Caramazza, 1992; Marshall & Newcombe, 1973; Morton, Patterson, Coltheart, Patterson, & Marshall, 1980).

Most reading researchers in the field (Beeson & Henry, 2008; Cherney, 2004; Ellis, 1993; Hillis & Caramazza, 1992; Marshall & Newcombe, 1973; Morton et al., 1980) agree on the core elements of this single word reading model. These include the pre-linguistic visual system, the non-lexical-phonologic, the lexical-phonologic and the semantic systems. In essence, single word reading is depicted as a series of processes that allow meaning and phonology to be derived from printed words (Beeson & Insalaco, 1998). The model also describes the different routes or pathways that allow the pronunciation of a word to be derived from the written word. In normal reading, a string of letters is perceived visually and transformed into a graphemic representation. The graphemic representation is held in a buffer, or visual word store, and is subsequently processed by lexical or nonlexical routes. In the direct, or lexical-semantic route, the orthographic representation activates the associated meaning via the semantic system, which activates the representation in the phonological output lexicon in preparation for speech production. The direct route accounts for whole word reading of familiar words. In the lexical nonsemantic route, whole words are processed, but meaning is not activated. In other words, the orthographic input lexicon activates the phonological processor, and meaning is bypassed. In the indirect, or nonlexical route, the written word is converted to the appropriate corresponding sounds, utilizing grapheme-to-phoneme conversion. This process is considered nonlexical because it does not rely on activation of words in the orthographic lexicon (visual word store). Readers use this route when they encounter unfamiliar words or attempt to pronounce non-words, and it can be relatively successful when reading regularly spelled words.

Four alexia syndromes have been described within the neuropsychological framework (Cherney, 2004). Table 1 presents a description of phonological, deep, surface, and semantic alexia based on the presumed disruption in the reading process and subsequent route through which reading is attempted. For example, surface alexia is characterized by unavailability of the semantic processor, so reading relies on the indirect route via letter-to-sound conversion. However, because comprehension is reliant on successful pronunciation of a word, words with ambiguous or irregular spellings (e.g. “ache” or “yacht”) are problematic and often misread (Beeson & Henry, 2008; Cherney, 2004). As illustrated in Table 1, the focus of treatment depends on the breakdown in the reading process. Typically,

Table 1

Alexia Syndromes Described by the Psycholinguistic Approach (Cherney, 2004) with Corresponding Focus of Treatment (Beeson & Henry, 2008)

Alexia syndrome	Breakdown in reading process	Route through which reading occurs	Distinguishing characteristics	Treatment focus
Phonological	Grapheme-to-phoneme correspondence	Direct route: Written word is matched to a corresponding word form in the visual word store; meaning is retrieved by activation of the semantic representation of the word by the semantic processor	Can read aloud real words, difficulty reading non-words or low frequency words; Visual errors (e.g., "mild" for "slid") in which target word is read as another word with similar letters	Strengthening letter-to-sound conversion; A "key word" approach is often used, in which training involves establishing at least one key word for each grapheme-phoneme pair targeted for treatment (typically starting with high frequency consonants); treatment proceeds to phonemic self-cueing so the client can derive the appropriate phoneme from a grapheme.
Deep	Grapheme-to-phoneme correspondence and lexical-semantic processes	Direct route: Reading is limited to a vocabulary of known words, restricted by imageability and part of speech	Difficulty or inability to read nonwords, visual errors evident; Semantic errors (e.g., producing synonyms, antonyms, or subordinates for a target word)	Strengthening letter-to-sound conversion; See above description. In addition, treatment may focus on strengthening semantics via written word-to-picture matching tasks.

Table 1 continued

Alexia syndrome	Breakdown in reading process	Route through which reading occurs	Distinguishing characteristics	Treatment focus
Surface	Semantic processor	Indirect route: Written word is transformed into spoken word via grapheme-to-phoneme correspondence rules in the letter- sound converter	Can read aloud nonwords and regular word with unambiguous orthographies, difficulty with irregular words that cannot be sounded out; comprehension is tied to successful pronunciation	Strengthening lexical-semantic processing; For example, treatment could involve presenting a set of training words in print with their written definitions and having the client write the target word in a sentence. Rapid visual presentation of a set of training words may also reduce overreliance on a phonological strategy (i.e. indirect route) when corrective feedback is provided during oral reading.
Semantic	Semantic processor	Lexical-nonsemantic route: Written word is matched to corresponding word form in the visual word store, but meaning is not retrieved via the semantic processor	Can read aloud fluently, but without meaning	Treatment may focus on strengthening semantics via written word-to-picture matching tasks. A set of functional words may be targeted as there may be limited generalization.

treatment for these specified alexia syndromes targets single word reading rather than comprehension of connected text.

Reading comprehension impairments in people with mild aphasia. The cognitive neuropsychological model is very useful in capturing linguistically based reading deficits in this population and indicating directions for intervention. However, it does not account for the reading comprehension deficits in people with more mild deficits in aphasia. These people often test within normal limits on single word reading, sentence comprehension, and functional reading of labels and signs included on reading assessments developed for PWA, like the Reading Comprehension Battery for Aphasia (LaPointe & Horner, 1998) (e.g., Coelho, 2005; Mayer & Murray, 2002; Sinotte & Coelho, 2007). Nevertheless, clinically they complain of reading problems. Most importantly, they lose activities important to them and are not eligible for prolonged or intensive treatment.

The reading deficits of individuals with mild aphasia are not well specified in the acquired alexia literature. Case studies document people who were once avid readers, with profiles post-stroke that include slow, effortful reading and difficulty with complex materials that require high-level skills such as inferencing, updating and integrating details. For example, Mayer and Murray (2002) describe an individual, WS, who obtained an Aphasia Quotient of 97, which exceeds the 93.8 cut-off score for a diagnosis of aphasia on the Western Aphasia Battery (Kertesz, 1982). WS, a former chair of a high school science program with a Master's of Education degree, expressed the desire to return to reading difficult materials. Performance on the Gray Oral Reading Test-3 (Wiederholt & Bryant, 2001) revealed slower than normal oral reading rate and decreased accuracy on comprehension questions corresponding to 8th, 10th, and 12th grade reading passages. The authors noted that WS had the greatest difficulty comprehending a passage based on irony. They suggest that "comprehension of the author's intent required high-level inferential skills, integration of details, and a revision or resolution of inconsistency" and that "WS was unable to utilize one or more of these higher-level abilities to process the meaning of the passage" (p. 731, Mayer & Murray, 2002). Although his text level reading abilities were estimated to be between the 8th and 10th grade level, this was recognized as a significant impairment given his educational and professional history. Additional case studies report individuals with mild anomic aphasia with a primary complaint of reading difficulty and difficulty sustaining concentration throughout longer texts (Sinotte & Coelho, 2007) and incomplete comprehension and forgetting recently read information (Coelho, 2005).

To summarize, the reading problems exhibited by people with mild aphasia do not appear to align with specified alexia syndromes. A small literature documents individuals with very mild aphasia who present with slow reading rate, difficulty concentrating and remembering text, and probable impairments in comprehension of complex material that require inference and integration of information. It may also be the case that individuals with mild aphasia and complaints of reading difficulties have phonological impairments, consistent with a phonological alexia (personal communication Cherney, November 2012). These individuals would consequently have breakdowns in grapheme-to-phoneme conversion with corresponding difficulties reading low frequency words. They may also demonstrate visual errors (e.g., "mild" for "slid") in which a target word is read as another word with similar letters or length. Given rereading and use of context, they are able to construct meaning. However, reading would likely be reported as slow, effortful, and cognitively demanding with incomplete comprehension particularly within complex materials. As described, the profiles of people with mild aphasia and complaints of reading difficulties are not well specified. Therefore, while this may be the case, it has not been studied.

In the next section, the processes involved in reading comprehension are described along with the role of working memory. Although successful reading comprehension depends upon a number of cognitive processes, including the ability to sustain attention, select relevant information and suppress or inhibit irrelevant information from text (Borella, Carretti, & Pelegrina, 2010), working memory is recognized as *particularly* important to reading comprehension (Carretti, Borella, Cornoldi, & De Beni, 2009; Daneman & Carpenter, 1980).

Reading Comprehension Processes

The acquired alexia literature described previously focuses primarily on the linguistic processes that occur at the word level. However, text level comprehension is a complex, interactive process that only just begins with word identification. Figure 1 illustrates an adaptation of the interactive activation model of reading (Perfetti, Landi, & Oakhill, 2005). Beyond word identification, three separate but interacting levels of representation of a text's meaning must occur for successful text comprehension. Sentence level representation is the word-for-word rendering of the text. At the proposition level, the reader extracts the core ideas from the

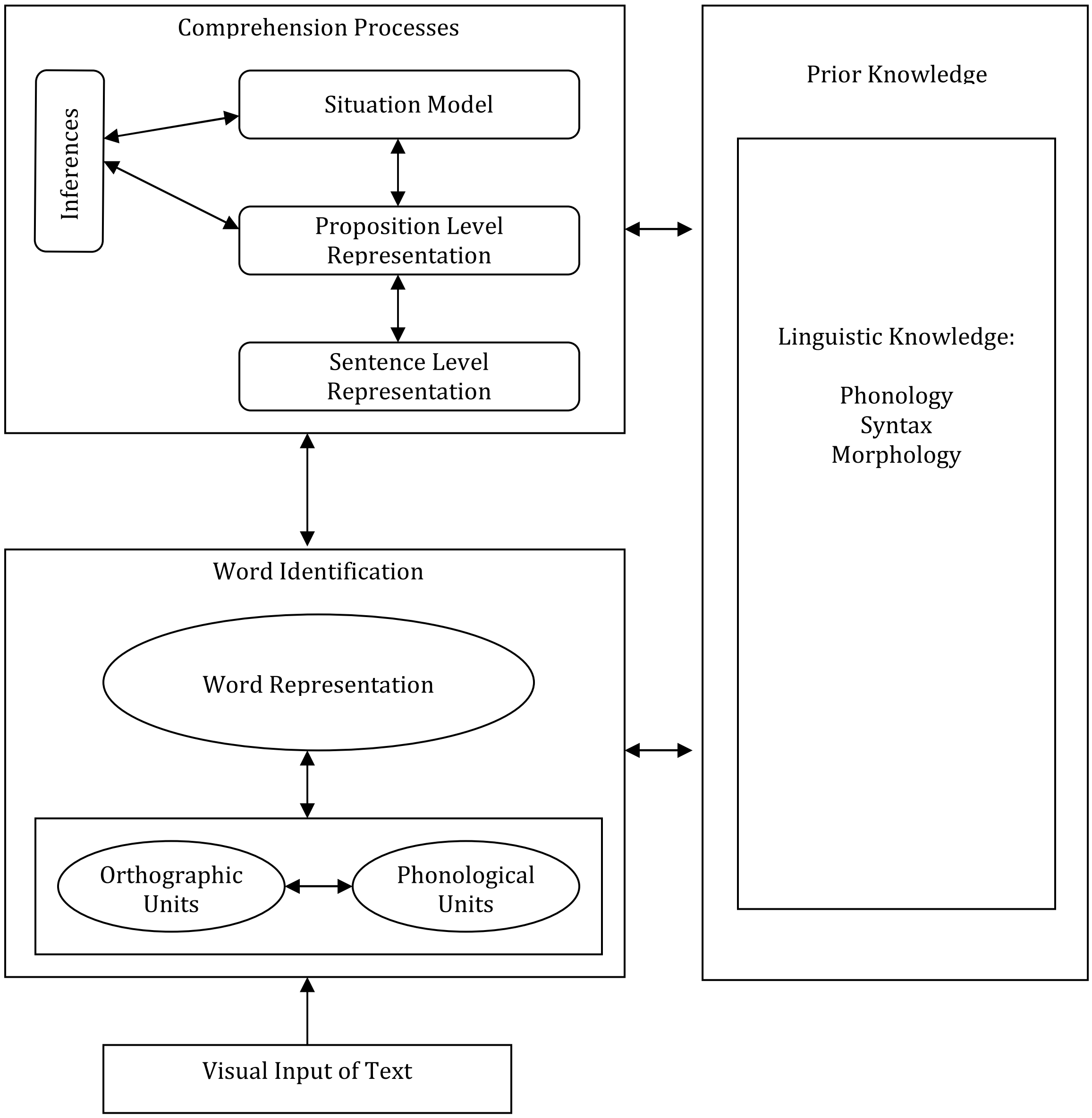

Figure 1

Interactive activation model of reading (Perfetti, Landi & Oakhill, 2005) literal text. As indicated by the boxes on the right of the figure, linguistic knowledge interacts with this level. With semantic knowledge, or meaning available, grammatical structures are parsed as the reader establishes relationships between words. At the highest-level, representation of the text's meaning, the reader creates a situation model, which is generated by integrating information from the text with relevant prior knowledge. According to Kintsch and Kintsch (2005), construction of a situation model requires going beyond literal and propositional representations: "Texts consist of words, and the textbase is a propositional structure (that is, word meanings combined into idea units). The situation model, in contrast, is not necessarily propositional, but may contain other components, such as visual imagery, emotions, as well as personal experiences" (p. 73). Finally, construction of a coherent situation model requires the reader to make inferences. Inferencing bridges elements in the text and allows the skilled reader to fill in gaps to provide the coherence necessary for comprehension (Perfetti et al., 2005). The interactive activation model presumes that readers can accurately identify words and retain sentence and propositional representations long enough to create meaningful situation models.

Role of working memory. Reading comprehension is heavily reliant on working memory (Ericsson & Kintsch, 1995). Readers must maintain new information in working memory as they read, while retrieving relevant information from background knowledge. They must then integrate information from these two sources to form ongoing representations of meaning (Ericsson & Kintsch, 1995). Baddeley's widely cited revised model of working memory accounts for these processes and specifies the systems that maintain auditory and visual information during the reading process. The model identifies the "central executive" as the mechanism charged with directing information to the proper stores within the working memory system. All of these working memory processes must happen while lower level processes such as word identification are also at work (Baddeley, 2000, 2002; Ericsson & Kintsch, 1995).

In Baddeley's and others' (Baddeley, 2002; Baddeley & Hitch, 1974; Daneman & Carpenter, 1980; Just & Carpenter, 1992) processing models, working memory is considered a system with limited capacity. Working memory capacity (WMC) is defined as the amount of activation (i.e., processing resources) available to meet the computational and storage demands of language processing. Just and Carpenter (1992) focus on how working memory capacity relates to language comprehension, suggesting that an individual's language comprehension depends on his or her working memory capacity. Accordingly, "if an individual had limited working memory capacity, this would be expected to lead to poorer storage and processing efficiency, which would result in slower and less efficient processing of language comprehension (p. 109, Wright & Shisler, 2005).

Daneman and Carpenter (1980) developed a working memory span task to test working memory capacity for language by examining both the processing and storage that occurs during reading. They argued, like Just and Carpenter (1992), that the working memory system has a limited capacity that must share resources between processing and storage. Therefore, they proposed that a measure that considered both operations could distinguish a good reader from a poor reader.

More efficient readers, for instance, would be able to integrate the information read, store it in long-term memory, and make it easily accessible for retrieval (Daneman & Carpenter, 1980). Their research demonstrated that reading span task predicted reading comprehension and was sensitive to individual differences in WMC in healthy adults (Daneman & Carpenter, 1980; Just & Carpenter, 1992; Wright & Shisler, 2005).

Whereas Daneman and Carpenter (1980) and Just and Carpenter (1992) argue that the working memory system has a limited capacity for computation and storage, Caplan and Waters (1999) suggest that there are separate working memory capacities for interpretative and post-interpretive processes that occur during reading. Their separate language interpretation resource theory asserts that there are two parts of working memory that contribute to language comprehension. Whereas the first aspect focuses on the initial meaning of an utterance that is unconsciously processed, the second component involves more conscious, controlled processing. Caplan and Waters (1999) suggest that in reading, working memory is employed after meaning of the sentence has been derived, in what is referred to as "second pass processing." Examples of second pass processing include: searching through a sentence for an antecedent pronoun, determining the truth value of a sentence, or applying the correct syntactic interpretation to a sentence (e.g., "assigning *boy* to *fell* in 'The boy who chased the girl fell'") (p. 110, Wright & Shisler, 2005).

As previously described, an emerging case study literature documents people with mild aphasia who complain of slow, effortful reading and difficulty with materials that require inferencing, updating and integrating details. This profile points to difficulty with working memory processes and construction of meaning that occurs in forming a coherent situation model. In addition, if these individuals also have phonological impairments, additional cognitive resources are needed at the word-identification level. Thus, the resources available for constructing meaning, resolving discrepancies, and monitoring their comprehension will be limited. As will be reviewed, there is evidence that supports reduced working memory capacity in PWA, which researchers link to the reading difficulties observed in PWA.

In the next section, the research documenting cognitive impairments, including working memory impairments, in PWA is reviewed. This is followed by an account of the resource allocation theory of attention in aphasia, which informs our understanding of the relationship between these non-linguistic cognitive impairments and language difficulties observed in PWA.

Cognitive Impairment in PWA: Attention, Working Memory and Executive Control

A well-established body of literature documents the existence of cognitive impairments in PWA. Furthermore, findings from numerous studies indicate that these cognitive difficulties, specifically deficits in attention, working memory, and executive control, may negatively affect the language production and comprehension abilities of PWA.

Attention impairment in PWA. Findings from a growing number of studies indicate that adults with aphasia have impairments in attention beyond their linguistic processing deficits. The behavioral literature reveals that, compared to healthy adults, PWA have diminished performance on a variety of attention tasks, even when these tasks do not have language demands. In one of the earliest investigations of attentional abilities of PWA, Robin and Rizzo (1989) found that a group of PWA had more difficulty orienting their attention to visual and auditory stimuli than a group of healthy adults. They reported that unlike the non-brain injured group, participants with aphasia did not benefit from cueing (i.e., a unidirectional arrow) that preceded auditory and visual targets, as there were no differences in their reaction times the valid, neutral, or invalid prompts.

In subsequent experiments, compared to healthy controls, participants with aphasia were found to perform more slowly, less accurately, or both on sustained attention tasks (Gerritsen et al., 2003; Korda & Douglas, 1997; Laures, 2005). In Gerritsen and colleagues' study investigating speed of processing in a group of unilateral ischemic stroke patients, the left hemisphere patients, 36% of whom were classified as having aphasia, demonstrated slower reaction times on semantic categorization tasks than an age-matched control group (Gerritsen et al., 2003). Korda and Douglas (1997) also explored reaction time (RT) in individuals with aphasia compared to a group of non-brain-injured adults. On a thirty-two minute visual vigilance task using letter and pattern stimuli, the aphasic group demonstrated longer reaction times than the healthy control group. Unlike the Gerritsen et al. findings (2003), which suggested that the performance decrements in the aphasic group were related to the linguistic demands of the task, the results of the Korda and Douglas study suggested that processing the nonlinguistic pattern stimuli was more attentionally demanding for individuals with aphasia than the letter stimuli. Within the aphasic group, the RT for the linguistic stimuli (i.e., the letter stimuli) was shorter than the RT for the non-linguistic pattern stimuli.

A more recent study conducted by Laures (2005) explored performance accuracy, as well as reaction time, in ten aphasic individuals and ten controls without neurological damage using auditory rather than visual sustained attention tasks. Similar to the Korda and Douglas (1997) study, participants were required to push a response button when the target was detected over a thirty-two minute time period. Laures included a linguistic task, in which the target was a low frequency occurrence word, and a nonlinguistic task, which required detection of a target tone. Results indicated that the aphasic group performed less accurately than the control group on both the linguistic and nonlinguistic auditory vigilance tasks. Examination of the response data also indicated a "high percentage of false alarms following missed targets for both types of stimuli [suggesting] that the aphasic participants did recognize the target stimuli" (p. 356). Laures noted that the variability in the aphasic participants' ability to respond within the allotted response time (i.e., 2500 ms) reduced their accuracy scores.

In addition to behavioral indications of attention impairment, physiological differences between PWA and healthy adults have been identified. An experiment using attention tasks that require vigilance revealed that PWA demonstrate reduced arousal (indicated by blood pressure and cortisol levels) compared to healthy adults

(Laures et al., 2003). Of interest to the current study, results suggested that the failure of PWA to demonstrate optimal arousal levels may be related to their poor self-monitoring of accuracy, as it appeared that "aphasic participants may not have perceived a need to increase arousal because they did not detect the errors" (p. 1145, Laures et al., 2003).

Working memory impairment in PWA. Compared to the attention literature, there has been less investigation of working memory impairment in PWA (Murray, 2004). Nonetheless, growing evidence suggests that PWA present with working memory deficits (Caspari et al., 1998; Friedmann & Gvion, 2003; Wright, Newhoff, Downey, & Austermann, 2003). Tompkins and colleagues (1994) investigated working memory ability of 25 individuals with left hemisphere brain damage, 16 of whom were diagnosed with aphasia, 25 right-hemisphere damage, and 25 neurologically healthy adults. They measured working memory capacity through a listening span task they developed, in which participants were instructed to judge the truthfulness of the sentence, and to then retain the final word of each sentence for subsequent recall. Participants with left-hemisphere damage made significantly more errors in recalling final words than healthy controls. In addition, when this group was divided into high and low auditory comprehension subgroups, results indicated that participants in the low comprehension group made significantly more recall errors. Wright et al. (2003) also reported reduced working memory performance in a group of PWA compared to a group of non-brain injured adults on the listening span task developed by Tompkins et al. (1994). Participants included 10 adults with fluent aphasia, 10 adults with nonfluent aphasia, and 10 healthy controls. Participants with aphasia made significantly more recall errors that the non-brain damaged controls.

Caspari and colleagues (1998) investigated the relationship between working memory capacity and reading in PWA. They used a modified version of the Daneman and Carpenter Reading Span Test (1980), in which sentences were shortened and the recall task was changed to a recognition task. The original span task requires participants to read aloud sentences presented in sets, with the sets increasing in number of sentences, and to recall the final word in each sentence. A participant's reading span is equivalent to the greatest number of words he or she recalls. Participants included 22 PWA who ranged in severity and type of aphasia. Results indicated a significant positive correlation between reading span and reading comprehension performance on the Reading Comprehension Battery for Aphasia (RCBA; LaPointe & Horner, 1998). Of interest to the current study, Caspari and colleagues concluded that working memory capacity is an accurate predictor of reading comprehension in PWA.

In this literature, it is difficult to ascertain if poorer performance by PWA on working memory tasks compared to healthy controls is due to a generalized reduced working memory capacity or due to the inability of PWA to perform the task because of their language impairment. Christensen and Wright (2010) recently conducted a study of verbal and non-verbal working memory in PWA to explore the effect of varying linguistic processing demands on participants' performance. Their study compared differences of a group of 12 PWA to 12 neurologically intact controls on three different n-back tasks that varied in their "linguistic load" or the degree to which an object couple rapidly elicit a name in a confrontation-naming task. Stimuli included fruit (i.e. highest linguistic load), "fribbles" (i.e., novel objects considered the semi-linguistic condition), and blocks (i.e. the non-linguistic condition). Results indicated that participants with aphasia performed worse than controls across the linguistically varied n-back tasks. Authors concluded that "the poorer performance of PWA on the working memory tasks was not solely a result of their language impairment" (p. 759). However, unlike the controls, PWA were less skilled at utilizing linguistic knowledge to increase performance on the "fribbles" n-back task, which authors suggested demonstrates the further decrement in working memory that results from a decreased ability to use a linguistic strategy to improve performance on verbal working memory tasks.

Executive control and resource allocation impairment in PWA. Deficits in executive control processes and the allocation of cognitive resources have been identified in PWA. Chiou and Kennedy (2009) compared the attentional switching ability of a group of PWA to controls using a "Go/No-go" task with minimized linguistic and cognitive demands. Participants were instructed to respond to a "go" stimulus by pressing a button on a game pad; rules were presented on the computer screen situated in front of the participant and were printed on a card, which remained in view. The rules, dictating a response, switched several times, in between sets of stimuli. For example, if the first rule was "Do not respond when you *see* F", the next rule would be "Do not respond when you *hear* E". Compared to age and education-matched healthy controls, PWA demonstrated reduced ability to switch flexibly between rules. In addition to being slower and less accurate, they were more likely to perseverate on a previous rule when switching from one rule to another than the controls.

PWA also demonstrate performance decrements on divided attention tasks, which rely heavily on executive control processes. "Divided attention tasks may be used to determine the pattern of performance alterations (i.e., interference, facilitation, no change) that result from competition" (p. 793, Murray et al., 1997b). The majority of the research in this particular area has focused on how divided attention or dual-task conditions that involve at least one linguistic task, affect the language skills of individuals with aphasia. However, there is evidence that PWA demonstrate divided attention deficits even when two non-linguistic tasks are used. For example, Erickson, Goldinger, and LaPointe (1996) conducted a study in which they compared the performance of a group on ten non-fluent aphasic adults to ten healthy controls on a complex attention task that involved identifying a target sound while simultaneously sorting cards according to their color. They "assessed aphasics' ability to detect nonlinguistic auditory stimuli during focused and divided attention, to determine whether previously observed decrements in divided attention are specific to linguistic stimuli, or if they reflect a more fundamental disruption of resource allocation" (p. 247, Erickson et al., 1996). As predicted, there were no significant group differences between aphasics and controls during the sound detection task in isolation. However, the PWA group performed less accurately, compared to the isolation condition and to the control subjects, during the divided attention condition with the added task of card sorting. The researchers noted that by avoiding the use of linguistic content in the target stimuli, their findings clearly identify attention allocation impairment in the participants with aphasia. Compared to healthy controls, PWA displayed "an inability to properly allocate attentional resources to auditory signals, even nonspeech signals, in the presence of competing stimuli" (p. 250, Erickson et al., 1996).

Role of metacognitive deficits in executive control. Researchers have suggested that metacognitive impairments in PWA contribute to their difficulties with resource allocation. Metacognitive processes have been described as a collection of high-level, interconnected executive control processes that allow us to regulate goal-directed behaviors (Keil & Kaszniak, 2002). Important examples include the ability to accurately self-monitor one's performance on a demanding task and make necessary adjustments (i.e., increase effort, motivation, select and apply strategies)(M. Kennedy & Coelho, 2005). LaPointe and Erickson (1991) suggest that participants with aphasia failed to allocate sufficient effort to a listening task under a dual-task condition because of their difficulty with self-monitoring the accuracy of their performance. Murray et al. (1997a) and Clark and Robin (1995) suggest that aphasic participants' subjective judgments of task demands and sense of effort, respectively, may account for their difficulties with resource allocation. These types of subjective measures represent a person's conscious judgment about the difficulties she experiences and are hypothesized to reflect the amount of attentional resources invested in carrying out a task. When task complexity or demands are increased, individuals should report greater task difficulty and increased effort because more resources are required to carry out the task successfully (Murray, 1999). In both studies, "despite poorer performance on language processing tasks, aphasic subjects' ratings of perceived effort or task difficulty, respectively, did not significantly differ from those of non-brain-damaged subjects; that is, the aphasic subjects demonstrated an inconsistent relationship among task complexity, perceived task difficulty, and actual task performance" (p. 101, Murray, 1999). Murray et al. (1997a) suggested that the discrepancy between participants' decreased performance and perceptions of task difficulty could also be due to "some unspecified motivational factor" (p. 412, Murray et al., 1997a). They proposed that future research should measure participants' perceptions of task difficulty as well as perceived effort and motivation on cognitively demanding tasks.

To summarize, PWA have been found to have an array of attention, working memory and executive control deficits. The different experimental tasks and associated theoretical frameworks employed across studies make it difficult to pinpoint the specific cognitive processing deficits that accompany aphasia. Yet, most of the experimental data point to behavioral and physiological differences in attention (Gerritsen et al., 2003; Laures et al., 2003), working memory capacity (Caspari et al., 1998; Wright & Shisler, 2005), and executive control or resource allocation (Hula & McNeil, 2008; LaPointe & Erickson, 1991; Murray, 2000; Murray et al., 1997b, 1997c, 1998; Tseng, McNeil, & Milenkovic, 1993), including difficulty self-monitoring performance and effort during complex tasks. The resource allocation theory (RAT) of attention in aphasia has been proposed to explain the relationship between these nonlinguistic cognitive impairments and the language symptoms observed in PWA. Additionally, the RAT drives the majority of cognitive intervention reported in the aphasia literature.

Resource Allocation Theory

McNeil and colleagues (1991) argue that purely linguistic models do not account for the performance patterns observed in aphasia, such as performance stimulability and variability. For example, the language performance of an individual with aphasia can often be influenced by nonlinguistic variables such as the loudness of the stimuli, the size and color of the print, and the effect of visual and auditory background noise. It is also the case that an aphasic person can perform a language function such as naming an object at one moment but not the next, even when the context and conditions remain the same. This inconsistency suggests that a separate nonlinguistic variable, such as internal-state, may govern the circumstances under which the skill is successfully performed (McNeil et al., 1991).

The resource allocation theory of attention (RAT) proposes that attention is the source of fuel for cognitive operations and processes that can be flexibly distributed or allocated among cognitive processes (Kahneman, 1973; McNeil et al., 1991; Murray, 1999). Within this model, there is debate over whether there is one single, undifferentiated reservoir of attentional resources (Kahneman, 1973) or multiple pools of attentional resources dedicated to specific processes (Gopher, Brickner, & Navon, 1982). Resource allocation theory asserts that although attentional resources are quantitatively limited, we can flexibly and simultaneously deploy and allocate resources to one or more activities (Kahneman, 1973; Murray, 1999). Kahneman (1973) suggests that the amount of attention invested in a specific task (e.g., cognitive, motor, perceptual) is dependent on task demands and that allocation of attention is regulated by factors such as the novelty of the task, intent or selective attention to a specific input, and arousal level in which both low and high arousal can have deleterious effects on task performance. Furthermore, failure to complete a task or set of tasks occurs if demands exceed the available capacity or if resources are inappropriately or inefficiently allocated (Kahneman, 1973; Murray, 1999).

Resource allocation models of attention concentrate on the process and outcome of cognitive tasks competing for limited resources. As Murray (1999) explains:

> When we complete concurrent or *dual tasks*, performance decrements for one or both tasks are anticipated only if the tasks compete for the same pool of resources; the more that tasks share these common resources, the greater the competition, and thus the greater the interference expected during dual-task performance (p. 92).

Applying Kahneman's (1973) resource theory to aphasia, McNeil and colleagues (1991) propose that language deficits may be partially explained by the limited capacity model of attention. They suggest that impairments in language processing and production may result from insufficient capacity, inefficient allocation, inappropriate allocation of attentional resources or a combination of all three (McNeil et al., 1991; Murray, 1999).

A substantial body of experimental research, which has primarily focused on investigating the linguistic performances of adults with aphasia under dual-task, or divided attention conditions, provides strong support for the resource allocation model of aphasia (e.g., LaPointe & Erickson, 1991; Murray et al., 1997b, 1997c, 1998; Tseng et al., 1993). As previously described, dual-task studies typically require participants to complete a linguistic task in isolation (i.e., single task condition) and simultaneously with a competing non-linguistic task (i.e., dual-task condition), such as card sorting or tone discrimination (Erickson et al., 1996; Murray, 2000; Murray et al., 1997c, 1998). This literature indicates that increased attention and resource allocation demands associated with dual-task conditions can negatively affect spoken language production (Murray, 2000; Murray et al., 1998) and auditory processing (LaPointe & Erickson, 1991; Murray et al., 1997b, 1997c; Tseng et al., 1993) in PWA.

To date, none of the dual-task studies in the aphasia literature have examined the effect of increased cognitive demands *specifically* on reading comprehension. The RAT, however, may explain the slow, effortful reading and difficulty with complex material reported by people with mild aphasia. Applied to these individuals, the model suggests that problems with high-level reading comprehension may result from their reduced attention/working memory capacities, their inefficient allocation of resources, or a combination of both. In addition, the metacognitive impairments documented in PWA, including judging task difficulty and monitoring their effort, may negatively affect their ability to efficiently or effectively allocate cognitive resources during reading. Based on RAT, researchers have suggested directly treating the attention and working memory problems in PWA to improve their reading abilities. As will be discussed, PWA may also benefit from metacognitive instruction and feedback related to carrying out cognitively demanding tasks.

Direct Attention Training (DAT) in PWA

Several researchers have explored direct attention training (DAT) as an aphasia intervention (e.g., Coelho, 2005; Helm-Estabrooks et al., 2000; Murray et al., 2006). DAT is based on the notion that attentional abilities can be improved by activating and stimulating the impaired attention system through repetitive drills, which promotes recovery of damaged neural circuits and improves attentional processing (Sohlberg & Mateer, 2001). While labeled "attention training," intervention programs that have been evaluated in the neurogenic literature target a broad range of attention, working memory and executive control processes (Butler et al., 2008; Duval et al., 2008; Sohlberg, McLaughlin, Pavese, Heidrich, & Posner, 2000). Direct process approaches aim to improve the underlying processing deficits by targeting specific cognitive domains such as sustained attention, working memory, and shifting from one task to another (Sohlberg et al., 2003). Researchers have evaluated the efficacy of DAT for improving attention and related processes in individuals with traumatic brain injury (e.g., Sohlberg et al., 2000). However, attention training is a relatively new area of investigation in the aphasia literature.

Preliminary evidence suggests that attention and related cognitive processes can be improved in individuals with aphasia using DAT (Barker-Collo et al., 2009; Sturm & Willmes, 1991; Sturm et al., 1997). These findings support the notion that practicing particular aspects of attention, working memory and executive control can promote recovery of associated networks in individuals with aphasia (Sturm et al., 1997). Initial research also suggests that improvements in attention, working memory and executive control resulting from DAT correspond to improved language skills in auditory comprehension (Helm-Estabrooks et al., 2000) and reading comprehension (Coelho, 2005; Mayer & Murray, 2002; Sinotte & Coelho, 2007).

DAT for reading comprehension deficits in PWA. Prior studies investigating the efficacy of DAT for treating reading comprehension deficit in individuals with chronic aphasia are reported in the literature. Coelho (2005) provided eight weeks of DAT via Attention Process Training-II (Sohlberg, Johnson, Paule, Raskin, & Mateer, 2001) to target reading impairment in an individual with mild aphasia and a primary complaint of reading difficulty and reported corresponding improvements in reading comprehension and perceived effort. The intervention included repetitive administration of sustained attention, working memory and executive control tasks, including selective, alternating and divided attention tasks. Treatment was delivered twice a week for eight weeks. Coelho suggested that the participant's reading improvements were attributable to improvements in attention and working memory. Although her reading rate did not increase, comprehension on weekly reading probes improved over the course of treatment. Coelho (2005) noted that the participant had to abandon the notion that she needed to read as fast as she had prior to her stroke, and that "once she stopped trying to read faster, perhaps her attentional resources were able to be re-allocated towards reading comprehension, which improved over time" (p. 282).

A follow-up study conducted by Sinotte and Coelho (2007) using a more intensive protocol for attention training (treatment sessions were administered three times per week for five weeks) yielded similar findings. No appreciable changes in the participant's reading rate were observed from pre to post-treatment. However, a decrease in the variability of her reading comprehension probe scores was observed in the second half of the study. The authors attributed the participant's changes in reading comprehension to improvement in the allocation of attentional resources, rather than improvement in linguistic skills.

Coelho (2005) and Sinotte and Coelho (2007) concluded that the participants in their studies experienced improved resource allocation as a result of the DAT. However, the studies' methods did not allow specifying the mechanism for improvement. The first study participant appeared to dedicate resources towards comprehending the text once she abandoned the notion of trying to read faster. It is not clear whether she was instructed to read more carefully, or if this was a strategy she devised on her own. Regardless, it is possible that metacognitive instruction, such as asking participants to estimate or predict task demands, may evoke improvements in resource allocation. It is also feasible that providing participants with feedback on their performance following treatment exercises could help facilitate their active mobilization of attentional resources to challenging tasks.

These two case studies encouraged further investigation of DAT as an intervention for reading comprehension in aphasia and suggested several methodological needs. Both of the studies utilized reading passages selected from magazine articles with five to six multiple choice questions created by the researchers. In the Sinotte and Coelho (2007) study, the researchers noted that the topics of the articles were pre-selected by the participant to facilitate high interest.

These studies would have benefitted from a standardized repeated measure that taps the processing demands associated with reading that is not highly influenced by readers' background knowledge or personal interests. Further, these studies would have been strengthened by incorporating metacognitive facilitation as part of the intervention given the difficulty PWA have with self-monitoring, accurately evaluating task demands, and mobilizing and allocating resources effectively during complex tasks (LaPointe & Erickson, 1991; Murray et al., 1997a, 1998; Tseng et al., 1993).

Pilot study. Lee and Sohlberg (2013) conducted a study to extend preliminary findings evaluating the potential impact of DAT on reading comprehension in PWA and to address the methodological needs suggested by previous case studies. The most recent version of the Attention Process Training program, APT-3 (Sohlberg & Mateer, 2010), was selected as the experimental intervention because it (a) contains a range of exercises that address sustained attention, working memory and resource allocation (i.e., executive control) that have been found to be impaired following aphasia; and (b) promotes metacognition, specifically self-monitoring through performance feedback and encouragement of effort and motivation as part of the attention training. The attention drills in APT-3 are organized by different attention domains, including sustained attention, working memory and executive control. The metacognitive features consist of eliciting participants' effort and motivation ratings and providing detailed performance data to participants to facilitate self-monitoring.

The primary purpose of the pilot study was to investigate whether there is a functional relation between APT-3 and improvements in reading comprehension in individuals with mild or moderate aphasia and concomitant reading impairment. It was hypothesized that APT-3 would improve participants' attention, working memory and executive control as measured by selected subtests from standardized cognitive assessments. If improvements in attention and working memory were observed, the researchers hypothesized that there would be an associated improvement in participants' reading comprehension based on the resource allocation theory (McNeil et al., 1991). Additionally, given the centrality of working memory in reading comprehension processes, it was predicted that emphasizing working memory tasks within the intervention would increase participants' working memory capacities (Daneman & Carpenter, 1980; Just & Carpenter, 1992) and potentially improve their second pass processing abilities (Caplan & Waters, 1999), which would translate to more efficient reading performance on the primary outcome measure, *AIMSWeb* maze reading (Shinn & Shinn, 2002). Finally, it was hypothesized that the metacognitive features of the intervention, specifically eliciting effort and motivation ratings and providing performance feedback to participants, would help them more effectively mobilize and allocate cognitive resources toward demanding treatment tasks with potential generalization to reading performance.

A secondary purpose of the pilot study was to examine the feasibility and utility of *AIMSWeb* maze reading (Shinn & Shinn, 2002) to efficiently measure improvements in reading comprehension over time. This task has the advantage of being standardized in its administration and scoring and not heavily influenced by readers' background knowledge or interests given the range of topics covered in the passages. While designed to identify reading problems in school age children (Shin, Deno, & Espin, 2000), maze reading is sensitive to the cognitive processes required for reading comprehension and has the potential to fill the existing gap in reading measurement in the aphasia literature.

A single subject non-concurrent multiple baseline design was employed across four participants with mild or moderate aphasia to evaluate potential changes in maze reading performance resulting from the APT-3 intervention. The intervention was delivered four times a week for eight weeks. Maze reading probes were measured repeatedly across baseline, intervention and maintenance phases of the investigation, with identical procedures for conducting probes across phases and participants.

Visual inspection of data revealed a basic effect between the intervention and maze reading for two of the study's four participants. In addition, there were improvements on select standardized measures of attention for all four participants. The maze task provided a standardized repeated measure of reading comprehension that was quick, simple to administer and score and was easily understood by the four participants. Issues related to measurement and candidacy were identified from the pilot study. Subsequently, participant inclusion criteria and pre-post-treatment measures of attention, working memory and reading were refined for the dissertation. The metacognitive component of the experimental intervention was also refined for the dissertation study based on findings from the pilot.

Research Questions

The purpose of the dissertation study was to evaluate the efficacy of APT-3 for improving reading comprehension in individuals with *mild* aphasia and concomitant reading difficulties. This study builds upon findings from the pilot study in several ways. First, inclusion and exclusion criteria were expanded based on characteristics of the participants who responded positively to the pilot intervention. Second, the metacognitive component of the intervention was refined to include individualized strategy instruction to promote participants' self-monitoring during challenging treatment tasks and support generalization to reading. When paired with attention training, metacognitive strategy instruction typically emphasizes facilitating efficient allocation of cognitive resources by providing feedback, goal setting and self-awareness enhancement. In addition, a non-verbal measure of working memory, administered pre and post-treatment, was added to the cognitive assessment protocol used in the pilot given the difficulty the pilot participants demonstrated completing the subtests with greater language demands. Lastly, measures were added to more carefully describe participants' reading abilities to discern whether disruption at the word identification level contributes to their text level comprehension difficulties. The refined assessments served as outcome measures to document potential changes in participants' cognitive and reading abilities that resulted from the experimental intervention. The study addressed the following questions:

1. Is there a functional relationship between implementation of a six-week intervention combining direct attention training and metacognitive facilitation, using the APT-3 program, and improvements in maze reading in individuals with mild aphasia and concomitant reading comprehension problems?
2. Do participants demonstrate improvements in attention, working memory, and executive control following the six week APT-3 intervention, as measured by Conners' Continuous Performance Test-II (CPT-II; Conners, 2000), the Spatial Span subtest of the Wechsler Memory Scale-Third Edition (WMS-III; Wechsler, 1997), the Pointing Span for Noun-Verb Sequences from the Psycholinguistic Assessments of Language Processing in Aphasia (PALPA; Kay, Lesser, & Coltheart, 1992), and select subtests from the Test of Everyday Attention (TEA; Robertson, Ward, Ridgeway, & Nimmo-Smith, 1994)?
3. Do participants demonstrate improvements in reading comprehension following the six week APT-3 intervention, as measured by the Gray Oral Reading Tests-4 (GORT-4; Wiederholt & Bryant, 2001)?
4. Do participants report changes in cognitive/language skills, reading, or other domains following the six week APT-3 intervention, as measured by semi-structured interview?

Hypotheses were grounded in McNeil and colleagues' (1991) resource allocation theory and the premise that the reading difficulties experienced by people with mild aphasia may result from their reduced attention/working memory capacities, their inefficient allocation of resources (i.e., executive control), or a combination of both. It was hypothesized that APT-3 would improve participants' attention, working memory, and executive control deficits, which would lead to an associated improvement in participants' reading comprehension.   In terms of the research questions, a functional relationship between APT-3 and improvements in participants' maze reading was hypothesized. The researcher hypothesized that the experimental intervention would elicit improvements in participants' attention, working memory, and executive control, as well as improvements in reading comprehension, as measured by selected outcome measures administered pre and post-treatment. Lastly, it was hypothesized that participants would report changes in various cognitive and language skills, including reading, in semi-structured interviews following the six-week APT-3 intervention.

CHAPTER III

METHODS

This chapter describes the research methods applied to the dissertation. First, the experimental design for the study is presented. Next, a description of participant characteristics is provided. Research procedures are then detailed, followed by a description of the experimental intervention, outcome measures, and analyses used to answer each of the research questions. The chapter concludes with a description of the methods for examining the social validity of the experimental intervention.

Experimental Design

A single subject non-concurrent multiple baseline (MBL) across participants design was used (C. H. Kennedy, 2005) to examine potential treatment effects. When single subject experiments are well designed and executed, they provide strong evidence of treatment efficacy to support evidence-based practices for specific client profiles and are particularly appropriate for initial investigation of a new treatment approach (Horner et al., 2005; Perdices & Tate, 2009). MBL designs are helpful for elucidating a functional relationship between an intervention and response in instances in which the effects of the intervention cannot be reversed. In a MBL design, the introduction of the intervention is staggered on different tiers to control for possible threats to internal validity.

The non-concurrent MBL design represents a variation in the separation of the different baseline to intervention tiers in time. Extending the length of the baseline condition across participants reduces threats to internal validity in a non-concurrent MBL design (C. H. Kennedy, 2005). Including six participants in the current study allowed the potential for demonstration of effect at six different points in time. This sample size also allowed the option of pairing participants (i.e., two participants run on the same baseline and treatment schedules). Decisions regarding the scheduling of baseline and when to initiate the treatment phase were based on participants' responses to intervention and visual inspection of plotted data.

Participants

Six participants with mild aphasia, concomitant cognitive deficits and difficulty with reading comprehension were recruited and selected for participation in the study based on the following inclusion and exclusion criteria.

Inclusion criteria:

1. Medically documented history of left hemisphere stroke.
2. At least 6-months post-stroke.
3. At least 18 years old.
4. Premorbidly right handed.
5. At least an eighth grade education and premorbidly literate in English as per self-report.
6. Receiving no concomitant speech-language therapy.
7. Visual acuity no worse than 20/100 corrected in the better eye.
8. Auditory acuity no worse than 25dB HL on pure tone testing, aided in the better ear.

9. Presenting with mild anomic aphasia as indicated by the Western Aphasia Battery Aphasia Quotient (WAB; Kertesz, 1982) with an Aphasia Quotient score of greater than or equal to 75.
10. Presenting with impairments in attention and/or working memory as measured by performance on standardized cognitive assessments, with impairment defined as one or more standard deviations below the mean on standardized scores for at least one of the measures.
11. Complaints of reading difficulty, including but not limited to, reports of slow, effortful reading, difficulty concentrating or remembering what has been read, need to reread for comprehension.
12. Reporting reading difficulty as primary complaint with high motivation to improve reading.
13. Expressing commitment to comply with intensive treatment protocol, i.e., 30-40 minutes of computer delivered tasks, six days per week for six weeks.

Exclusion criteria:

1. Any other neurological condition (other than cerebral vascular disease) that could potentially affect cognition or language functioning, such as Parkinson's Disease, Alzheimer's Dementia, or traumatic brain injury.
2. Any significant psychiatric history prior to the stroke, such as major depression or psychotic disorder requiring hospitalization. Active substance abuse.

Participants were recruited via flyers distributed at the Rehabilitation Institute of Chicago's (RIC) aphasia groups and classes. One participant responded who did not meet criteria. Six participants were identified who met criteria and were sequentially enrolled in the study. One participant subsequently withdrew during the baseline phase due to transportation problems. Thus, a sixth participant was identified who met criteria and enrolled.

Table 2 details the participants' characteristics. The participants ranged in age from 56 to 66 years (M = 61.5 years). Etiology of aphasia included left-hemisphere ischemic cerebrovascular accident (CVA) for four of the participants and left-hemisphere hemorrhage for two participants. Time post onset of stroke ranged from 9 to 80 months (M =44 months).

All six participants were classified as having mild aphasia as indicated by an Aphasia Quotient (AQ) score greater than 75 on the Western Aphasia Battery (WAB; Kertesz, 1982). At pretreatment, AQ scores ranged from 77.9 to 91.2 (M = 86.3). The AQ, which reflects the severity of the spoken language deficit in aphasia, is derived from the verbal and auditory comprehension portions of the battery. The Cortical Quotient (CQ), a more general measure of cortical functioning and intellectual ability, according to Kertesz, is obtained from all of the language modality subtests, the construction, visuospatial, and calculation subtests, as well as the Raven's Coloured Progressive Matrices. CQ scores ranged from 69.9 to 92.3 (M = 78.2).

Table 2

Participant Characteristics

Participant	Age	Gender	Ethnicity	Education	Previous occupation	Etiology/Type of Stroke	Months post-onset	WAB AQ	WAB CQ	WAB Reading Subtest
PITGL	62	Male	African American	16	Camera operator	Left MCA embolism	75	86.0	77.1	100
DAVJE	56	Male	African American	19	Accountant	Left ICA embolism	38	77.9	72.9	83
CULMI	66	Male	White	16	Theater owner/producer	Left embolism posterior limb of internal capsule and globus pallidus	43	90.2	92.3	100
KINPE	66	Male	White	14	Risk reviewer for bank	Left MCA embolism	9	85.7	77.7	94
DUREV	60	Female	African American	13	Actress/Dancer	Left subarachnoid hemorrhage	80	86.7	69.9	61
WOLTO	59	Male	White	15	Machinist	Left hemorrhage	20	91.2	79.5	92

Note. MCA = middle cerebral artery, ICA = internal carotid artery, WAB AQ = Western Aphasia Battery Aphasia Quotient, WAB CQ = Western Aphasia Battery Cortical Quotient.

Performance on the Reading Subtest of the WAB ranged from 61 to a ceiling score of 100 (*M* = 88.3). Four of the six participants presented reading impairments characteristic of phonological alexia, as indicated by performance on subtests from the Psycholinguistic Assessments of Language Processing in Aphasia (PALPA; Kay et al., 1992). Their intact real word reading combined with difficulty reading nonwords suggested a breakdown in grapheme-to-phoneme correspondence. DAVJE's performance, in contrast, was suggestive of a surface alexia. KINPE's reading performance did not appear to align with a specified alexia syndrome. In accordance with eligibility criteria, all six participants reported complaints of reading difficulty that included slow, effortful reading, difficulty concentrating or remembering what has been read, and a need to reread for comprehension. In terms of reading motivation (criterion 12), all of the participants reported a desire to improve reading, though DUREV commented that she was never a "big reader."

Procedures

Participants completed six weeks of intervention, as well as approximately 3-4 hours of cognitive and language assessments pre-and post-treatment. All sessions took place at RIC in a treatment room in the Center for Aphasia Research and Treatment or a conference room within the main hospital. Participants were seen individually. The researcher carried out recruitment, informed consent, screening procedures and delivery of the intervention. Bi-weekly probes were also administered by the researcher. 20% of probes were randomly selected and scored by a research assistant who was blind to the phase in which probes were delivered to establish inter-rater reliability. A research assistant with a doctorate in speech-language pathology, who was not involved in treatment procedures, administered and scored the pre and post-treatment assessments. Exit interviews facilitated by the researcher and the assistant were conducted with participants following the post-treatment evaluation. Table 3 illustrates the time sequence of the study activities. A description of procedures is presented in the following sections.

Table 3

Time Sequence of Study Activities

Week	Activities
	Participant Recruitment
Week -2: Session 1	Informed Consent, Interview/Screening, Determination of eligibility, Baseline probe 1
Week -2: Session 2	Pre-treatment assessment, Baseline probe 2
Week -1	Baseline maze reading probes 3-5
Day 0	Begin treatment
Weeks 1 to 6	APT-3 Intervention
	Bi-weekly visits to RIC for probes and treatment
Week 7	Post-treatment assessment and exit interview
Week 9	3 week maintenance probe

Note. The number of baseline probes administered was extended for participants 3-6, adding to the time required for pre-treatment activities.

Sessions one and two: Consent, screening and assessment activities. Participants completed informed consent, screening activities and a battery of language, cognitive and reading assessments during the first and second sessions. Informed consent was obtained by the researcher, who was a speech-language pathologist with over seven years of experience communicating with PWA. She verbally reviewed the consent using supported communication techniques and ensured that the participant understood the purpose, procedures, and risks and benefits of the study, as well as the rights of a research subject. Following the consent process, activities in session one verified and documented eligibility for the study. The assessment battery, continued over session two, provided descriptive data to characterize the population and document pre-treatment performance on language, cognitive and reading measures. The schedule is in Table 4. See Appendix A for a full list of cognitive, language, and reading assessments.

Probing schedule and conditions. Maze reading probes were measured repeatedly across all phases of the investigation, with identical procedures for conducting probes across phases and participants. No feedback regarding the accuracy of their responses on the maze reading was provided. A detailed description of the maze reading measure is provided in the "Outcomes" section.

Baseline phase. Baseline was established with a minimum of five data points and no visible trend upon visual inspection of the data. Due the non-concurrent design, the length of baseline phase was extended across participants to reduce threats to internal validity and establish experimental control (C. H. Kennedy, 2005). Decisions regarding the scheduling of baseline and when to initiate the treatment phase were based on participants' responses to intervention and visual inspection of plotted data.

Table 4

Schedule for Sessions One and Two

Session one		Session two	
Estimated Time	Activity	Estimated Time	Activity
10 min	Consent procedure	60 min	Cognitive skills assessment
20 min	Interview to document eligibility based on inclusion criteria 1-6 and 11-13	60 min	Reading skills assessment
	Hearing and vision screening to document eligibility criteria 7-8		
10 min	Screening/Practice probe	5 min	Baseline probe
	Baseline probe		
30 min	Language assessment to verify eligibility based on inclusion criterion 9 (WAB AQ score)		
30 min	Cognitive assessment to verify eligibility based on exclusion criteria 10		

Intervention phase. Cessation of the baseline condition and initiation of the treatment were also contingent upon baseline stability. Maze reading probes were collected twice a week and plotted for visual inspection following training.

Maintenance phase. Maintenance probes were obtained three weeks following completion of the intervention for five of the six participants. One of the participants was not available because he had moved out of state.

Experimental Intervention

The most recent version of Attention Process Training, APT-3 (Sohlberg & Mateer, 2010) was used as the experimental intervention. The program divides attention exercises into two main categories: basic sustained attention and attention requiring executive control, including selective attention, working memory, suppression, and alternating attention. The pilot study (Lee & Sohlberg, 2013) established that PWA could complete APT-3 exercises with minimal supports depending on the linguistic demands of the tasks. Participants reported that they enjoyed the treatment tasks and that the length of treatment sessions and duration of the intervention were acceptable.

Task selection. APT-3 tasks were selected based on the literature that documents impairments in attention, working memory and resource allocation in PWA (Korda & Douglas, 1997; LaPointe & Erickson, 1991; Murray, 1999, 2002; Tseng et al., 1993; Wright & Shisler, 2005). The rationale and method for task selection were retained from the pilot study. In a typical session, participants completed six attention exercises, three or four of which were selected to engage working memory. This focus on working memory was based on the literature that documents people with mild aphasia with slow, effortful reading and difficulty comprehending and retaining high-level materials (e.g., Coelho, 2005; Mayer & Murray, 2002; Sinotte & Coelho, 2007). Basic sustained attention tasks and working memory tasks were administered during the first three to four weeks and executive control tasks (categorized by the APT-3 program as suppression and alternating attention) were added during weeks four through six. See Table 5 showing sample APT-3 tasks used in the current study.

Progression of tasks. The APT-3 program uses adaptive training where trials are administered slightly above capacity and tasks increase in difficulty as the participant improves. Participants were required to score at least 80% accuracy on two consecutive trials of an exercise in order to advance to more difficult treatment tasks (i.e., more task demands such as increased response items or increased rate of presentation) (Coelho, 2005; Sinotte & Coelho, 2007). Tasks were discontinued when criteria were met or when there was a need to minimize participant frustration with exceedingly difficult tasks. When criterion was not met after several trials, tasks were occasionally discontinued to maintain participant motivation and reduce boredom. As in the pilot study, certain tasks were modified to decrease the linguistic demands or to support participants when verbal responses were required by the task. For example, on a working memory task that requires participants to listen to a sentence and rearrange the words of the sentence in alphabetical order, participant DUREV was presented with the written words in addition to the auditory stimuli and allowed to use the written support to generate a verbal response. On tasks that required participants to listen to a series of numbers and verbally rearrange the numbers in ascending or descending order, participants were asked to write their responses during sessions completed independently so that the researcher could check accuracy and compliance with home practice.

Metacognitive component. In addition to the drill practice, APT-3 includes two features designed to promote metacognitive behavior: self ratings for effort and

Table 5

Sample APT-3 Tasks with Description and Corresponding Attentional Domain

Domain	Task Name	Description
Basic Sustained	Listen for 1 animal sound (slow/fast)	Auditory task requiring response to target sound in a 3 minute series
	Listen for 2 ascending numbers (slow/fast)	Auditory task requiring response when ascending numbers present in 3 min series
	Matching clock times	Matching task using digital and analog clock faces
	Listening for 2 Numbers (slow/fast)	Auditory task requiring response to 2 target numbers in 3 minute series
	Number comparison	Visual task requiring number comparison judgment (e.g. 7 > 3)
Working Memory	Animals 2-back	2-back task using animal stimuli
	Abstract Shapes 2-back	2-back task using shape stimuli
	Add 3	Mental math task requiring addition of 3 to digits presented in a series
	Alphabetize sentences	Mental task requiring rearranging words in alphabetical order
	Ascending numbers	Mental math task requiring rearranging digits presented in a series in ascending order
Suppression	Adult/Child Voices (slow/fast)	Auditory task requiring response to congruent stimuli (i.e., Adult voice speaking word "adult")
	Left/Right (slow/fast)	Visual task requiring response to congruent stimuli (i.e., word "left" presented on the left side of the screen)
Alternating	Above/Below (slow/fast)	Visual task requiring switching between congruent and incongruent stimuli
	Serious/Silly (slow/fast)	Auditory task requiring switching between congruent and incongruent intonation

motivation and presentation of detailed performance data following task completion. The rationale for including participants' subjective effort ratings was grounded in the literature, described previously, that suggests that PWA may inappropriately evaluate task demands and therefore allocate insufficient effort or resources, resulting in performance decrements on demanding tasks (e.g., Clark & Robin, 1995; Murray et al., 1997a). Following each attention exercise, participants were asked to rate their effort and motivation on a scale from one to ten (one = little to no effort/motivation, ten = highest effort/motivation). In addition to promoting self-awareness of task demands, ratings also helped the investigator select exercises that were appropriately challenging without compromising participants' engagement.

The performance feedback component of the intervention was based on research that suggests PWA demonstrate nonoptimal arousal because they do not detect their errors on demanding tasks or view tasks as challenging (Laures et al., 2003). Additional rationale for providing feedback comes from the literature, described previously, that suggests deficits in self-monitoring contribute to PWA's difficulty with resource allocation (LaPointe & Erickson, 1991). Furthermore, research in the area of naming treatment for PWA has identified feedback and the ability to monitor errors and modify behaviors on the basis of feedback as critical outcome variables (McKissock & Ward, 2007). After performing each APT-3 task, participants were shown their results on a line graph that captured their performance in terms of correct responses, omissions and commissions and were encouraged to reflect on their performance. See Figure 2 for sample performance data on one of PITGL's tasks. Findings from the pilot study suggested that the feedback component of the intervention may help participants identify error patterns and more effectively mobilize and allocate their attention to maximize performance on challenging tasks.

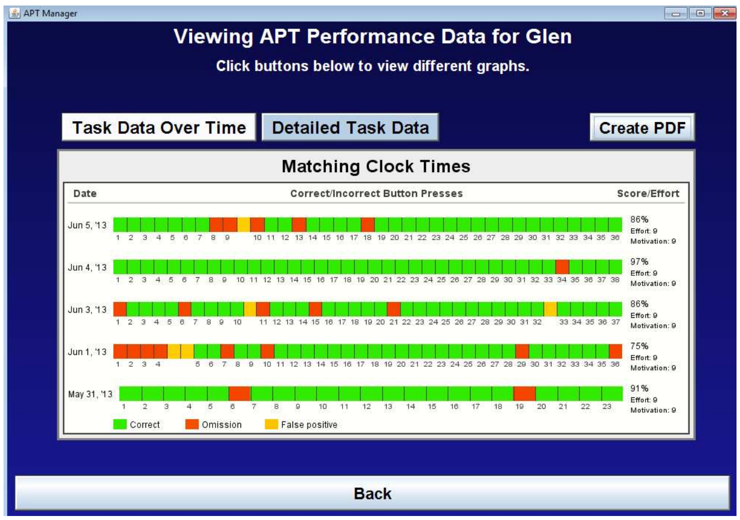

Figure 2

Screenshot showing performance feedback for PITGL from Attention Process Training-3 program

Metacognitive strategy training, facilitated by the researcher, was also included in the intervention. Metacognitive strategy training refers to teaching self-monitoring and goal-setting strategies to support generalization of improved attention and executive control to daily living tasks. When paired with direct attention training (DAT), metacognitive strategy instruction typically emphasizes facilitating efficient allocation of cognitive resources by providing feedback, goal setting and self-awareness enhancement (Lee, Harn, Sohlberg, & Wade, 2012). There are currently no data regarding the efficacy of strategy instruction to promote generalization of improved attention in people with aphasia. There is, however, growing support for integrating DAT and metacognitive strategy training within the pediatric acquired brain injury population (Butler et al., 2008; Galbiati et al., 2009; Luton, Reed-Knight, Loiselle, O'Toole, & Blount, 2011; van't Hooft et al., 2007). In this literature (Butler et al., 2008; Luton et al., 2011), participants were instructed to use strategies targeting skills such as task readiness and on-task performance during treatment sessions as well as on various homework tasks. Similarly, participants in the current study were instructed to use their strategies in their everyday lives and specifically during home reading activities, though no direct instruction of strategy utilization outside of the APT-3 exercises was provided. Strategies were developed collaboratively with participants and refined throughout the six-week intervention as exercises increased in difficulty and task demands changed. Examples of these individualized metacognitive strategies are provided in Table 6.

Treatment duration and intensity. Treatment was delivered over a six-week period of time. Participants were asked to complete a 30-40 minute treatment session six days a week. APT-3 is a computerized program that can be delivered by a clinician and the exercises can then be synched to a USB drive to allow clients to practice independently at home. Participants came to RIC for treatment sessions twice a week. They were provided with a USB drive containing the APT-3 program to complete the additional four practice sessions per week at home independently. Participants were provided with paper practice logs to track

Table 6

Metacognitive Strategies Targeted in APT-3 Intervention

Participant	Metacognitive Strategies Targeted (with personalized wording in quotations)
PITGL	• Prepare environment • Re-engage in middle of task • Deep breath
DAVJE	• Re-engage in middle of task • Repetition • Positive self talk o "Confidence!"

CULMI	• Prepare self and environment
	  o "Focus, Focus, Focus!"
	• Repetition
	• Task engagement throughout
	  o "Stay in the game"

KINPE	• Re-engage in middle of task • Verbal mediation • Repetition
DUREV	• Clarify instructions before beginning task • Focus • Positive self talk o "Yes I can!"
WOLTO	• Anticipate what's coming next • Deep breath • Repetition • Stay engaged despite mistakes o "Let it go"

their home practice. In addition, the researcher tracked their weekly compliance by uploading participants' electronic practice data.

Home reading activities. Participants were asked to log their home reading activities throughout the six-week intervention. They were not instructed on how much or what type of reading to complete during the intervention period. While no direct reading or strategy instruction was provided outside of the APT-3 exercises, participants were asked to indicate whether or not they used their metacognitive strategies during home reading activities. Home practice and reading logs were reviewed during the RIC sessions twice a week. Figure 3 shows a sample reading log from participant DAVJE during week two of treatment. In his log, DAVJE reports reading various articles from the *Wall Street Journal* and *The Sun Times* for fifteen to thirty minutes per day and indicates "yes" to using his two metacognitive strategies.

The average number of participant reported minutes read per week was calculated. Post-hoc analysis of "ratio of change" over the six-week intervention period was calculated to capture potential changes in reading that occurred during the intervention. Ratio of change in participant reported weekly reading was determined by dividing the difference in minutes read between weeks 1 and 2 and weeks 5 and 6 by the summed minutes read from weeks 1 and 2 (i.e.,[(5+6) – (1+2)]/(1+2).

WK 2

Home Reading Activities

DAY	WHAT DID I READ? (newspaper, magazine, novel, e-mail, letter)	DID I USE MY STRATEGY?	START TIME	END TIME	TOTAL TIME
Example	• *Sun Times local news article* • *Email*	*yes* *no*	*9am* *5:45*	*9:45am* *6:05pm*	*45 min* *20 min*
MONDAY	Fiscal Cliff WSJ after Years of Growth Banks are Pruning Branches	yes	11am	11 15am	15 min
TUESDAY	Mom and Pop Run With the Bulls — WSJ How To Save More For Retirement — WSJ	yes	5pm	5 30pm	30 min
WEDNESDAY	Years of Growth, Banks Are Pruning Their Branches WSJ	yes	8pm	8 15pm	15 min
THURSDAY	Sun Times WSJ	yes	6pm	6 30pm	30 min
FRIDAY	Firms Reach for Vitamins WSJ	yes	7pm	7 15	15 min
SATURDAY	Upper Room Bible magazine Sun Times	yes	3pm	3 30pm	30 min

Figure 3

Sample home reading activities log

Outcome Measures

Maze reading. Repeated measures (i.e., probes) for reading comprehension were obtained using eighth grade level "Standard Maze Passages" developed by *AIMSWeb* (Shinn & Shinn, 2002). Maze reading is a standardized, curriculum-based measure that is used to identify reading difficulties, monitor progress, and make program evaluation decisions for elementary and middle school students. The maze task is appealing because it can be administered repeatedly and yields multiple data points to chart an individual's growth over time (Tolar et al., 2012).

Maze passages consist of a multiple-choice cloze task completed while reading silently. The first sentence of a 200-400 word passage is left intact, but thereafter, every seventh word is replaced with three words inside parentheses, one word that is from the original passage and two distracter words (Shinn & Shinn, 2002). During probe measures, participants were asked to read the maze passage silently for three minutes and to circle the word in parentheses that appropriately completes each sentence. The number of correct cloze items completed by participants in the three minutes allotted was counted and recorded. The total number of cloze items per passage ranged from 48 to 53. There were a total of 30 different eighth grade level passages of equivalent difficulty. One passage was administered for each probe, and the order of passages was randomized so that participants were either presented with passages in ascending or descending order.

The psychometric properties of maze reading as a curriculum-based measure are well documented. Maze reading tasks have been found to be reliable and valid for measuring reading comprehension skills of school age children and adolescents

(Brown-Chidsey, Davis, & Maya, 2003; Shin et al., 2000; Tolar et al., 2012). Among a large sample of middle school students, alternate form reliabilities range from .70 to .91, when an outlier value related to a specific passage was removed. Moderate correlations with other reading comprehension measures, such as the Woodcock-Johnson III Passage Comprehension, have been reported with coefficients ranging from .41 to .70 (Tolar et al., 2012). The sensitivity of the maze task for detecting improvement of reading proficiency has been documented with significant growth rates for elementary school student over a school year (Shinn & Shinn, 2002). Maze reading has also been implemented with adults attending a basic literacy program. Moderate validity coefficients between the maze task and norm-referenced measures, high alternate form reliability, and sensitivity to student growth following ten weeks of reading instruction were reported for a sample of 57 adults reading below an eighth-grade level (Bean & Lane, 1990).

The technical adequacy of maze reading for individuals with aphasia has not been established. However, in the pilot study, PWA with reading difficulties understood and were able to complete the task. In addition, this repeated measure was sensitive to improvements associated with implementation of APT-3 for two of the study's four participants who also demonstrated improvements on standardized cognitive measures (Lee & Sohlberg, 2013). The maze task may tap the working memory and attention demands requisite for reading comprehension. For example, the cloze task requires readers to attend to various features of the text (e.g., referent for a pronoun) and to hold onto the meaning of a particular sentence long enough to select an appropriate response. In addition, readers must retain and update meaningful information to comprehend an entire story. Successful performance on maze passage reading also requires strategic reading behavior (e.g., rereading to clarify confusion and ensure accurate selection) and self-monitoring of comprehension. It has been suggested that maze reading is a more direct measure of reading comprehension than alternatives, such as an oral reading fluency measure, because correct replacements are generated by language processes that help the reader build a mental model of the text (Tolar et al., 2012). The maze task requires silent reading thus is more closely matched to functional reading than an oral reading measure.

Pre- and post-treatment assessment. A battery of cognitive assessments was administered pre- and post-treatment to evaluate participants' attention and working memory abilities and monitor possible response to intervention on standardized cognitive assessments (see Appendix A). The Gray Oral Reading Test-4 (GORT-4; Wiederholt & Bryant, 2001) was also administered pre- and post-treatment to evaluate potential changes in reading fluency and comprehension resulting from the intervention. The measures are described below.

The Conners' Continuous Performance Test-II (CPT-II; Conners, 2000). The CPT-II is a computer-administered test of sustained attention and vigilance. Respondents are required to press the space bar when any letter except the target letter "X" appears. The test lasts for approximately 14 minutes during which letter stimuli are presented in blocks and the inter-stimulus intervals are 1, 2, and 4 seconds. The CPT-II demonstrates strong psychometric properties (Conners, 2000) and the ability to differentiate between clinical and nonclinical groups (Woodin, 1999). The CPT-II has shown sensitivity to treatment change including medication trials for children with ADHD (Conners et al., 1996; Conners, March, Fiore, & Butcher, 1993; Kirby, VandenBerg, & Sullins, 1993) and adults with neurological impairments (White & Levin, 1999). The CPT-II is an appropriate measure of sustained attention for PWA that has been used successfully in aphasia treatment studies (Cherney, 2010a; Lee & Sohlberg, 2013)

The Test of Everyday Attention (TEA; Robertson et al., 1994). The TEA measures various aspects of attention using everyday materials. It is based on an imagined trip to Philadelphia in which the examinee is asked to perform everyday tasks in different scenarios. Subtests of the TEA correlate significantly with existing measures of attention; for example, for the Map Search and Stroop, $r = .51$; for Visual Elevator and Wisconsin Card Sorting Test, $r = .42$(Robertson, Ward, Ridgeway, & Nimmo-Smith, 1996). Discriminative validity of the TEA has also been reported, indicating that the majority of TEA subtests are able to discriminate patients with attentional deficits from the normal, non-brain injured population (Chan, 2000). The TEA has three parallel forms and high test-retest reliability for non-brain injured controls ($r = .59$-.86) and stroke patients ($r = .41$-.90) (Robertson et al., 1996). Three subtests were selected for the current study: (1) Map Search, a measure of visual attention and scanning; (2) Visual Elevator, a measure of attentional switching; and (3) Telephone Search Dual Task, a measure of resource allocation. The Telephone Search Dual Task provides a “dual task decrement” score that reflects the cost of performing a visual search task while simultaneously counting a string of auditory tones. Selection was based on measures that tap the attention domains targeted by the experimental intervention that can be completed by PWA given their language constraints (Lee & Sohlberg, 2013).

The Spatial Span from the Wechsler Memory Scale-3rd Edition (WMS-III; Wechsler, 1997). The Spatial Span is a test of working memory. This subtest includes a forward and backward span task, which are combined to form a single score. In the forward span task, the examiner points to a series of blocks, and the examinee is asked to point to the same blocks in the same order. In the backward span task, the examiner points to a series of blocks, and the examinee is asked to point to the same blocks but in the reverse order. The Spatial Span is an appropriate measure of working memory for PWA because unlike a digit span test, it does not require verbal responses. The WMS-III battery demonstrates robust psychometric properties, including internal consistency (0.85-0.99) and test-retest reliability (0.75-0.99) (Corporation, 1997; Iverson, 2001). Test-retest reliability of the Working Memory Index, which includes the Spatial Span, is 0.80 for older adults. Construct validity has been documented with factor analytic studies that differentiate the dimensions of memory captured by performance on the WMS-III in both clinical (i.e. neurologically impaired) (Bradley Burton, Ryan, Axelrod, Schellenberger, & Richards, 2003) and non-clinical samples (Millis, Malina, Bowers, & Ricker, 1999). In these studies, the Spatial Span subtest consistently aligned with the construct of working memory.

The Span for Noun-Verb Sequences from the Psycholinguistic Assessment of Language Processing in Aphasia (PALPA; Kay et al., 1992). This test provides a measure of processing abilities in phonological short-term storage that may be relevant to sentence comprehension of PWA. Examinees are instructed to look at a page with eight black and white pictures representing nouns (e.g., mouse, hat) and verbs (e.g. cut, boil). The examiner says the names of noun-verb and noun-verb-noun sequences and asks the examinee to point to the items in the same order. The sequences used constitute semantically anomalous 'sentences' equivalent to subject-verb and subject-verb-object structures (Kay et al., 1992). Similar to the Spatial Span (Wechsler, 1997), this task measures working memory span. Yet, it requires verbal processing and storage of increasingly complex sequences of linguistic information. Because the test requires only a pointing response, it is appropriate for respondents with speech and language production difficulties. The developers did not carry out psychometrically adequate measures of validity or reliability, though norms from a sample of neurologically healthy and aphasic adults are provided for many of the subtests. Norms are not currently available for the Pointing Span subtest, nor is there an alternate form.

The Gray Oral Reading Tests-4th edition (GORT-4; Wiederholt & Bryant, 2001). The GORT-4 is a test of oral reading rate and comprehension. It consists of passages of increasing length and difficulty that are followed by comprehension questions. The GORT-4 has been standardized on more than 1,600 students and demonstrates absence of gender and ethnic bias. It has been established as a valid measure of oral reading rate, accuracy, fluency, and comprehension that correlates with other established measures of reading. Two equivalent test forms, A and B, are available. High internal consistency has been demonstrated with coefficients that exceed or round to .90. Test-retest reliability has been demonstrated with coefficients ranging from .78 to .91. (Wiederholt & Bryant, 2001). Although the GORT-4 was developed to quantify oral reading and comprehension skills of school aged children, it has been applied to persons with aphasia in research contexts (e.g., Beeson & Insalaco, 1998; Lee & Sohlberg, 2013; Orjada & Beeson, 2005; Sinotte & Coelho, 2007). While it has strong psychometric properties, there are no psychometric data on individuals with aphasia.

Post-treatment interviews. Semi-structured interviews were conducted by the researcher following the intervention and post-treatment evaluation. The purpose of the interviews was (a) to elicit feedback from participants on whether they perceived changes in cognitive and/or language domains that they attributed to participation in the study, and (b) to measure the social validity of the intervention. Interviews followed the general script presented in Appendix B. Questions were open-ended, and interviewers pursued inquiry based on participants' responses to elicit authentic responses. Supported communication techniques (e.g., writing key words, use of pictograms, rating scales) were used to support participants' expression and to verify that the interviewers understood their responses. While the researcher facilitated the interviews, an assistant who was not involved in the intervention was present to clarify participants' responses and to minimize experimenter bias. The interviewer and assistant carefully rephrased and confirmed participants' responses throughout the interviews to ensure participants' views were captured despite any difficulties with verbal expression.

Analyses

Analyses for each of the four research questions are detailed in the following section.

Evaluating functional relationship between APT-3 and improvements in maze reading (research question 1). Visual inspection of graphed performance data across baseline and intervention conditions was used as the primary method of analysis to address research question one. Visual analysis allows interpretation of the level, trend, and variability of performance occurring during the baseline and intervention conditions (Horner et al., 2005; C. H. Kennedy, 2005; Parsonson & Baer, 1992). Visual analysis of the within- and across-conditions data was used to determine if participants' changes in maze reading were a function of the intervention provided.

Tau-U was calculated to supplement visual analyses and quantify changes in maze reading resulting from the intervention. Attempts to apply statistical analysis to single-case research (SCR) are gaining popularity (e.g., Perdices & Tate, 2009; Shadish, Rindskopf, & Hedges, 2008). Tau-U is a new index for analysis of SCR data that combines nonoverlap between phases with intervention phase trend; the statistic also allows the option of controlling for undesirable baseline trend (Parker, Vannest, Davis, & Sauber, 2011). There are a number of nonoverlap methods, such as percentage of nonoverlapping data (PND), percentage of all nonoverlapping data (PAND), and percentage of data points exceeding the median (PEM) that are easy to calculate, visually accessible, and have the benefit of being distribution-free (i.e., not requiring parametric assumptions about data distribution or scale type) (Parker, Vannest, & Davis, 2011). However, these methods can easily result in over- or underestimation of effect of intervention. PND (Scruggs, Mastropieri, & Castro, 1987), for example, which is interpreted as the percentage of data in the treatment phase exceeding the single highest baseline data point is particularly sensitive to outliers. Moreover, traditional nonoverlap methods are inappropriately applied when there is positive trend in the baseline phase and positive trend in the intervention phase that would be inadequately captured by an index of level alone (Parker, Vannest, & Davis, 2011).

Tau-U has the advantage of capturing positive trend in the intervention phase that can be a critical index of improvement, particularly for interventions, like direct attention training, in which gradual learning or responsiveness over time is predicted. Tau-U also provides the option of correcting for baseline trend. Positive trend in the baseline phase suggests the client may have improved even without intervention. Parker cautions that "ignoring positive baseline trend risks erroneous conclusions about the cause of change" (Parker, Vannest, Davis, et al., 2011, p. 3). Because positive baseline trend was observed in the pilot study (Lee & Sohlberg, 2013), Tau-U was an especially appropriate statistical technique to apply to data from the current study.

Evaluating changes in attention, working memory, and reading comprehension pre and post-intervention (research questions 2 and 3). The Wilcoxon signed-rank test (Wilcoxon, 1945) was selected to compare participants' performance on pre- and post-treatment assessment measures. The Wilcoxon signed-rank test is a non-parametric equivalent to the dependent *t*-test, which is appropriate when comparing within subject scores (i.e., scores that come from the same participants). A non-parametric test was necessary to address research questions two and three due to the small sample size and violation of normality of the sample distribution presented by the current study (Field, 2009).

Evaluation of participant perceived changes in language, cognitive skills, reading, or other domains following intervention (research question 4). Two post-treatment interview questions were used to evaluate perceived changes. See Interview Guide (Questions 1-2) in Appendix B. First, participants were asked if they had noticed any changes since participating in the research project. The interviewers pursued inquiry with follow up questions to ensure understanding of participant perspectives. Participants were also asked to provide examples if they indicated that they had noticed a change in their abilities (e.g., "Where have you noticed changes in your attention?"). Next, participants were asked if anyone else has noticed and/or commented on any reported, perceived changes. Post-treatment interviews were audio-taped and transcribed verbatim by the researcher. Applying methods outlined by Cherney, Halper, and Kaye (2011), the researcher read through each transcription and identified comments pertaining to perceived changes related to participation in the intervention. Comments were defined as one or more sequential statements in response to a question by the interviewer, as well as statements made by the interviewee to clarify a response. The researcher read through the transcripts several times, making notes about participants' perceived changes in order to identify repeated and/or patterned comments. Comments related to each other were placed into initial categories, which were refined to eliminate redundancies. Related categories were then grouped together to form broader domains of change (Cherney, Halper, et al., 2011).

A second reviewer who was not involved in the assessment, intervention, or interview processes was trained to identify comments pertaining to perceived changes using one of the interview transcripts. Following training, the reviewer independently read through the five remaining transcripts and identified all comments to establish point-to-point inter-rater reliability. The reviewer also coded 50% of the interviews into the categories of perceived change established by the researcher.

Social Validity

Kennedy defines social validity as "the estimation of the importance, effectiveness, appropriateness, and/or satisfaction various people experience in relation to a particular intervention (2005, p. 219). Social validity is an important construct as consumers are more likely to comply with treatment protocols they perceive to be useful and beneficial. A common measure of social validity is participant questionnaire (C. H. Kennedy, 2005). However, obtaining authentic information from a written questionnaire presents challenges for any study involving participants with aphasia, particularly those who identify reading difficulties as a chief complaint.

In this study, questions relating to social validity of the experimental intervention and study procedures were included in semi-structured post-treatment interviews. See Interview Guide (Questions 3-8) in Appendix B. Participants were asked to rate their satisfaction with the intervention on a scale of 0-10 (0 = not satisfied, 10 = highly satisfied) and whether they would recommend this project to a friend with aphasia. They were also asked to comment on the length of the treatment, taking the reading probes, and the APT-3 treatment. Interviews were transcribed verbatim and reviewed by the researcher. Participants commented on aspects of the treatment (i.e., drills and metacognitive strategy training) throughout the interviews. Therefore, comments pertaining to their endorsement of the intervention were also included in the social validity analysis. Endorsement was defined as positive comments related to usefulness, engagement, or preference (e.g., "I liked the drills", "that strategy helped me"). A second reviewer read through the interview transcripts and coded (1) satisfaction (0-10), endorsement of (2) drills, (3) metacognitive strategy training, (4) length of treatment, (5) maze reading, and (6) recommendation of program.

CHAPTER IV

RESULTS

This chapter begins by presenting data on treatment intensity and participant reported home reading activities. Next, the results from three sets of analyses are presented: (1) multiple baseline design (MBL) study data, (2) pre and post comparison of formal testing and (3) participant reported data.

Treatment Intensity Data

Treatment was carried out over six weeks. Participants completed two APT-3 sessions per week at RIC facilitated by the researcher. They were asked to complete an additional four home practice sessions, for a total of six sessions per week. See Table 7 for a summary of APT-3 sessions completed. It is notable that, on average, participants met or exceeded the home practice requirement, with the exception of DUREV who completed less than the assigned number.

Table 7

APT-3 Sessions Completed

Participant	Clinician facilitated sessions per week	Average home practice sessions per week
WOLTO	2	4.0
DAVJE	2	6.5
CULMI	2	5.5
KINPE	2	4.3
DUREV	2	3.6
PITGL	2	5.0

Home Reading Activities

Participants logged their home reading activities throughout the six-week intervention. They were not instructed on how much or what type of reading to complete during the intervention period. Table 8 shows participant reported reading activities, including minutes read per week and various reading materials. Amount of reading ranged from an average of 65 to 602 minutes per week. Ratio of change in participant reported reading from the first two weeks of treatment to the last two weeks of treatment ranged from 0 (i.e., no change in amount of reading) to 1.3 (i.e., more than twice as much reading). Participants reported reading an assortment of materials including email, catalogues, newspapers, and various magazines.

Maze Reading Data

The number of correct cloze items completed by participants in the three minutes allotted was counted, recorded, and plotted for visual inspection. Inter-rater reliability for 20% of probes, randomly selected and scored by a research assistant who was blind to the phase in which probes were delivered, was 100%. Figure 4 illustrates maze reading accuracy across baseline, treatment, and a three-week maintenance condition for the participants. Note that for the first two participants enrolled, PITGL and DAVJE, the treatment was introduced after establishing a sufficiently stable baseline using visual inspection (approximately two weeks). The next participants to enroll, KINPE and DUREV, subsequently received an extended baseline phase lasting six weeks. WOLTO received a twelve-week baseline. Due to scheduling restrictions, CULMI, the last participant to enroll,

Table 8

Participant Reported Home Reading Activities

Participant	Reading time per week (minutes)		Average per week (minutes)	Ratio of change	Reading material
PITGL	Week 1	450	602	0.52	• Snail mail/email • Red Eye from the Chicago Tribune • Sun Times • Magazines
	Week 2	540			
	Week 3	550			
	Week 4	570			
	Week 5	810			
	Week 6	690			
DAVJE	Week 1	125	171	0.21	• Wall Street Journal • Jazz magazine • The Economist • Bible
	Week 2	135			
	Week 3	210			
	Week 4	240			
	Week 5	150			
	Week 6	165			
CULMI	Week 1	75	80	0.93	• Magazines (Esquire, People, US Weekly) • Novel • Sun Times • NY Times (week 4) • Chicago Tribune (weeks 5-6)
	Week 2	130			
	Week 3	255			
	Week 4	230			
	Week 5	185			
	Week 6	210			
KINPE	Week 1	80	73	NA	• NY Times • Novel • e-mail
	Week 2	90			
	Week 3	15			
	Week 4	105			
	Week 5	NA			
	Week 6	NA			
DUREV	Week 1	20	65	1.3	• Essence • Black Enterprise • Cookbook • Email • Catalogues
	Week 2	50			
	Week 3	120			
	Week 4	40			
	Week 5	90			
	Week 6	70			
WOLTO	Week 1	390	358	0.0	• AOL news • Boat building book (weeks 5-6)
	Week 2	360			
	Week 3	345			
	Week 4	300			
	Week 5	420			
	Week 6	330			

Note. NA = not available, home reading log not returned.

was run on the first tier schedule (i.e., intervention immediately following stable baseline). Extending the length of baseline across participants in a non-concurrent MBL design reduces threats to internal validity and helps establish experimental control.

Visual inspection of the data revealed a change in maze accuracy over baseline levels with the introduction of the intervention for three of the study's six participants: DAVJE, CULMI, and WOLTO. Table 9 summarizes three key indices of visual analysis applied to plotted data from the six participants: level change from baseline to treatment, positive trend in the treatment phase, and immediacy of effect. Note that for participant DAVJE, there was an immediate effect upon initiation of the intervention; mean level change from baseline (M = 11.5) to treatment (M = 14.5) and a slight increase in trend in the treatment phase were also observed. Similarly, immediacy of effect, mean level change from baseline (M = 9) to treatment (M = 13), and positive trend in the treatment phase were observed for CULMI. For WOLTO, visual inspection indicates both an increase in level from baseline (M = 8.3) to treatment (M = 11.1) and positive trend in treatment. Visual analysis did not reveal a relationship between APT-3 and maze reading for the other three participants.

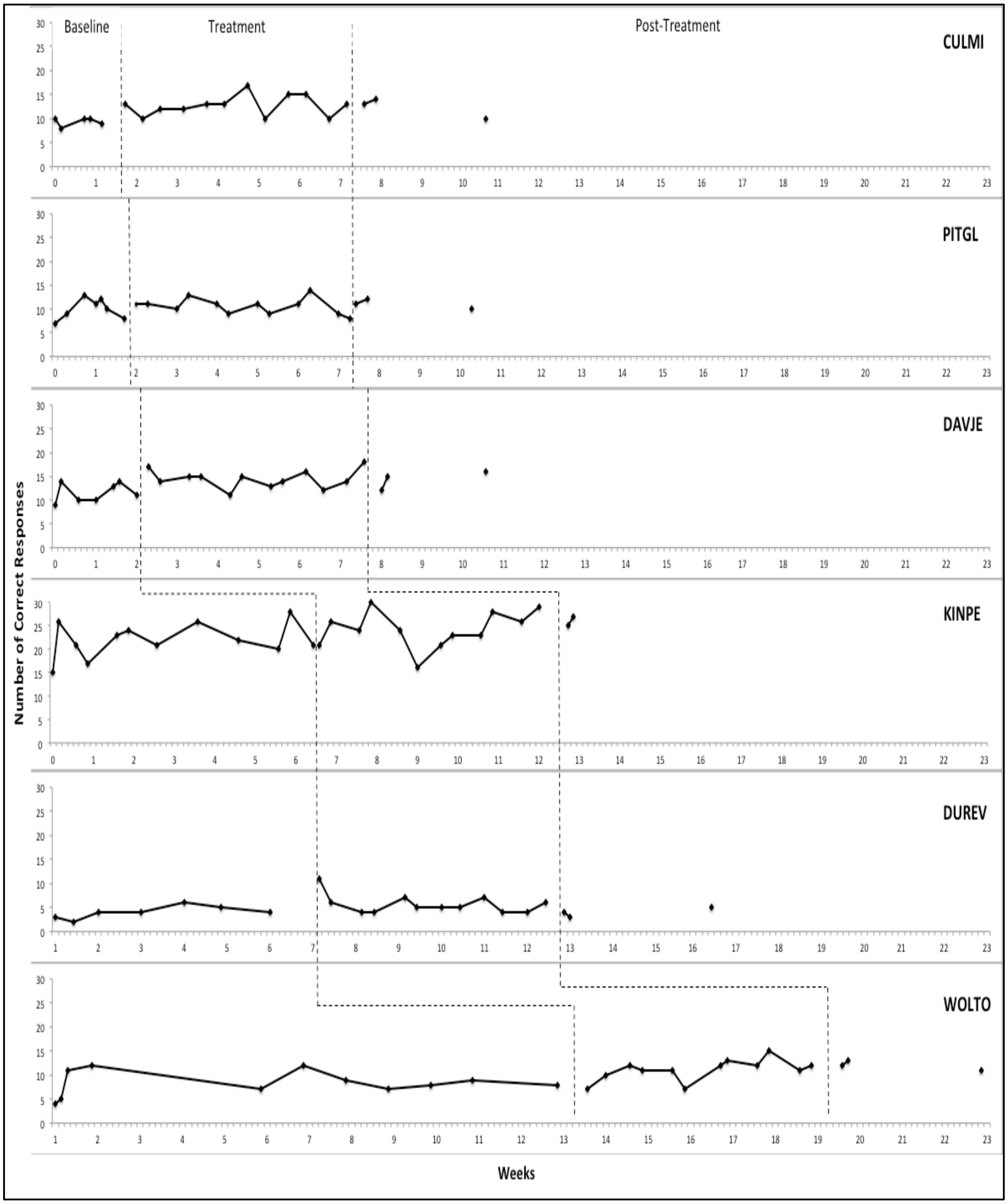

Figure 4

Maze reading accuracy across baseline, treatment, and post-treatment conditions

Table 9

Visual and Quantitative Analyses of Participants' Maze Reading Performance

Participant	Visual Analysis			Quantitative Analysis	
	TX *M* > BL *M*	Increasing trend in TX	Immediacy of effect	Tau-*U*	*p* value
PITGL	no	no	no	.19	.47
DAVJE	yes	yes	yes	.63*	.02
CULMI	yes	yes	yes	.85**	.00
KINPE	no	no	no	.35	.14
DUREV	no	no	yes	.42	.14
WOLTO	yes	yes	no	.54*	.02

Note. TX = treatment phase, BL = Baseline phase; *M* = mean; Tau-U (Parker, Vannest, Davis, & Sauber, 2011). Baseline trend corrected for participants DAVJE (BL trend = .33) and DUREV (BL trend = .47)

*$p < .05$

**$p < .001$

Tau-U was calculated to augment visual analyses and quantify potential treatment effects. As previously described, Tau-U considers nonoverlap between baseline and treatment conditions, as well as treatment phase trend. This index can also identify and correct for unfavorable baseline trend. See results presented in Table 9. Note that baseline trend was corrected for participants DAVJE and DUREV given respective slopes of .33 and .47. Tau-U analyses yielded statistically significant results for participants DAVJE and WOLTO at $p < .05$ and CULMI at $p < .001$.

Pre- Post-Treatment Comparisons

Group analysis. The Wilcoxon signed-rank test was calculated to analyze participants' pre and post-treatment performance on assessment measures. Results were statistically significant for two of the cognitive outcome measures. See Table 10. At post-treatment (median = 6.5), participants performed significantly better on the TEA Map Search, a measure of visual attention and scanning, than at pre-treatment (median = 3.5), $T = 15.00$, $p < .05$. At post-treatment (median = 7.5), participants performed significantly better on the PALPA pointing span for Noun-Verb Sequences than at pre-treatment (median 5.0), $T = 21.00$, $p < .05$. Participants did not perform significantly better from pre- to post-treatment on the reading assessments.

Individual performance: cognitive measures. Participants' performance on pre and post-treatment cognitive assessments are summarized in Table 11. Data in the table are presented first for the three participants (i.e., "maze responders") for whom visual analysis revealed a basic effect between the APT-3 intervention and maze reading. Data from the three participants (i.e., "maze non-responders") for whom a basic effect was not demonstrated is presented in the next three columns. The number of participants in the sample who demonstrated improvements on measures from pre-to post-treatment is illustrated in the last column.

Table 10

Related Samples Wilcoxon Signed Ranks Test Results

Outcome Measure	Pre-treatment Median	Post-treatment Median	T statistic	p value
CPT-II Clinical Profile Confidence Index (%)	55.53%	50.0%	3.00	.225
TEA				
Map Search (1st minute)	3.5	6.5	15.00	.041*
Visual Elevator Accuracy	5.5	4.5	8.00	.891
Dual Task Decrement	4.50	4.75	2.00	.075
WMS Spatial Span	7.5	8.0	7.50	1.00
PALPA Span for Noun-Verb Sequences (out of 12)	5.0	7.5	21.00	.026*
GORT-4				
Fluency	.705	.700	13.00	.599
Comprehension	.188	.213	11.00	.917

Note. CPT-II = Conners' Continuous Performance Test-II, TEA = Test of Everyday Attention, WMS = Wechsler Memory Scale-3rd Edition, PALPA = Psycholinguistic Assessments of Language Processing in Aphasia, GORT-4 = Gray Oral Reading Tests-Fourth Edition. Calculation based on raw scores reported for the PALPA and GORT-4 and scaled scores for TEA and WMS. * indicates statistical significance at $p < .05$.

Table 11

Pre- and Post-Treatment Performance on Cognitive Measures

	Maze Responders						Maze Nonresponders						
	WOLTO		DAVJE		CULMI		KINPE		DUREV		PITGL		# of subjects demonstrated improvement
Cognitive Measures	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	
CPT-II Clinical Profile Confidence Index (%)	60.7	**42.7**	45.6	50.0	80.2	**50.0**	50.0	50.0	41.2	50.0	99.9	**50.0**	3/6
TEA													
Map Search (1st minute)	<1	***6**	3	***7**	6	6	4	***7**	3	***6**	5	***11**	5/6
Visual Elevator Accuracy	6	**7**	5	4	5	5	6	***9**	3	**4**	10	3	3/6
Dual Task Decrement	7	5	4	***14**	4	2	7	3	5	**6**	<3	***4.5**	3/6
WMS Spatial Span	8	**10**	13	8	7	***12**	6	6	4	**5**	11	8	3/6
PALPA Span (out of 12)	7	**9**	4	**6**	5	**6**	7	**9**	2	**3**	5	**9**	6/6

Note. CPT-II = Conners' Continuous Performance Test-II, TEA = Test of Everyday Attention, WMS = Wechsler Memory Scale-3rd Edition, PALPA = Psycholinguistic Assessments of Language Processing in Aphasia. Bolded items correspond to improved performance. Raw scores reported for the PALPA. Scaled scores reported for TEA and WMS. * indicates ≥ 1 SEM in SS (3 points).

The Conners' Continuous Performance Test-II (CPT-II; Conners, 2000) provides a confidence index, based on examinees overall performance, that indicates a clinical (CI > 50%) or nonclinical (CI < 50%) classification compared to a clinical sample with attention deficit disorder. Two of the responders (i.e., CULMI and WOLTO) demonstrated improvements on the CPT-II, such that performance at post-treatment was consistent with a "nonclinical" population (i.e. CI < 50%), whereas performance at pre-treatment was consistent with a "clinical profile" (i.e. CI > 50%). Five participants, two of whom were maze responders, demonstrated gains on the Map Search subtest of the TEA (Robertson, Ward, Ridgeway, & Nimmo-Smith, 1994). Scaled score gains on the TEA Visual Elevator were observed for three participants, including one of the responders (WOLTO). Three participants demonstrated scaled score improvements on the Dual Task Decrement; DAVJE (responder) demonstrated a ten-point improvement. Three participants (two responders) demonstrated improvements on post-treatment performance on the WMS spatial span. All six participants demonstrated raw score gains on the PALPA Span for Noun-Verb Sequences.

Individual performance: reading measures. Performance on reading measures is shown on Table 12. Data for the three responders is presented in the left hand columns, followed by data for the non-responders. The last column indicates how many subjects from the sample demonstrated improvements from pre- to post-treatment. Three participants, two of whom were responders (DAVJE, WOLTO) performed better from pre-to post-treatment on GORT Fluency, a composite of oral reading accuracy and timing. KINPE, DUREV, and WOLTO demonstrated improved comprehension scores at post-treatment testing.

Participant Reported Data from Post-Treatment Interviews

The researcher initially identified a total of 77 comments related to perceived changes across the six post-treatment interviews. Following training on one of interviews, inter-rater reliability for identification of comments on the remaining five transcripts was 77.1%. Discrepancies were discussed between the researcher and the independent reviewer. It was determined that the reviewer identified fewer comments than the researcher due to a pattern of grouping adjacent responses into a single comment. The researcher and reviewer reached consensus on a total of 75 comments that were grouped into nine categories. Related categories were then grouped together to form broader domains of perceived change. For example, the categories of reading comprehension, amount of reading, reading selection, and reading behavior were grouped together in a single domain. Similarly, attention and memory categories were grouped into a cognitive domain. Inter-rater reliability for categorization of comments into domains was 93%.

Table 12

Pre- and Post-Treatment Reading Performance

	Maze Responders						Maze Nonresponders						
	WOLTO		DAVJE		CULMI		KINPE		DUREV		PITGL		
	Stories 3-12		*Stories 3-10*		*Stories 3-10*		*Stories 3-12*		*Stories 1-4*		*Stories 3-10*		# of subjects demonstrated improvement
GORT-4	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	
Fluency	12/ 100	**16/ 100**	38/ 80	**52/ 80**	19/ 80	17/ 80	52/ 100	44/ 100	5/ 40	2/ 40	11/ 80	**17/ 80**	3/6
Comprehension	38/ 50	**42/ 50**	21/ 40	14/ 40	31/ 40	29/ 40	33/ 50	**37/ 50**	7/ 20	**13/ 20**	30/ 40	27/ 40	3/6

Note. GORT-4 = Gray Oral Reading Tests-Fourth Edition. Bolded items correspond to improved raw score performance.

Table 13 shows the number of participants with comments across five domains of perceived change: cognition, reading, communication, activities of daily living/community participation, and confidence/attitude. Four of the participants noted improvements in their attention following the intervention. Five participants reported perceived changes in memory, and four participants reported changes related to communication. All of the participants referenced changes either in their reading skills or reading behaviors that they attributed to participation in the study. Four participants perceived improvements in their reading comprehension; four participants identified reading more often and engaging with different types of materials than before the treatment. Five of the participants referenced needing to reread less for comprehension or retention. Four participants reported changes related to activities of daily living or community participation. Five participants perceived changes in their attitude or confidence. Table 14 reports participant perceived changes in each of the categories.

Table 13

Perceived Changes Derived from Post-Treatment Interviews

Domain	Cognition		Reading				Communication	ADLs/ Community	Confidence/ Attitude
Category	Attention	Memory	Reading Comprehension	Amount of Reading	Reading Selection	Reading Behavior/ rereads less			
# of Participants indicating change	4	5	4	4	4	5	4	4	5

Table 14

Examples of Perceived Changes Across Categories

Category	Examples provided to illustrate perceived change
Attention	"my attention span is better, I know that" –PITGL "overall I focus more than I did before six weeks ago, believe it or not, I do" -DAVJE "Focus, focus, focus—I learned to focus more." –CULMI "I concentrate on uh on uh stuff because you made me me listen to focus on it, focus on it. I pay attention to what I'm doing." -CULMI "seems like I can concentrate more fully now than before." -KINPE
Memory	" I can, uh hold along, hold on to stuff better" –PITGL PITGL: "a lot of times I'm telling you, people have talked, you can talk to me, used to go in one ear and outta there and five minutes from there, you asked me what we's talked about, it gone Interviewer: and that was before we started mid-May PITGL: yeah yeah Interviewer: and so now PITGL: I can, you know, I retain it a little more "I picked up on things I would repeat, I mean I could uh repeat a sentence, you tell me a sentence, I could tell it back to you." -CULMI "I think I'm memorizing more; I can't think I can believe that, I think I am…the drills they helped that" –KINPE
Reading Comprehension	"I seem to be able to read better than before. I understand more… I understand a little bit better, what I'm reading, than I was like at the beginning" -WOLTO "I think I read clearer now." –KINPE "It [reading] is better. It's much better, actually…I remember words. I remember some words, I remember." -DUREV

Table 14 continued

Category	Examples provided to illustrate perceived change
Amount of Reading	"my guess is that I'm doing more reading that I was doing before" -DAVJE Interviewer: How much would you say you're reading? KINPE: That was twice as much I think. "I'm reading more now than I was back then. Back then I was reading maybe 3 times, 3 or 4 times a week, whereas now I'm reading all, everyday." -WOLTO
Reading Selection	Interviewer: so the topics are different? CULMI: yeah Interviewer: you were looking at sports and entertainment… CULMI: yeah Interviewer: and now you're looking at different topics too? CULMI: well sports and entertainment was easy for me Interviewer: okay CULMI: easy, read that all the time, and this I read politics because of the uh, political problem Interviewer: yeah CULMI: now I want to read more because…when I read for myself every day, I read the paper everyday like this (gestures, leaning in close to table) 'what happened? Oh he stole money. Oh he did this, he did that.' Now I just read because it hurt me, 'oh god, I can't read' I would read entertainment, and I read sports. Now I read everything! Interviewer: after your stroke, did you start reading books? WOLTO: oh no Interviewer: is this the first time you're picking up another book? WOLTO: yeah, yeah.

Table 14 continued

Category	Examples provided to illustrate perceived change
Reading Behavior/ Rereads less	CULMI: I mean that I read for understanding now. Interviewer 1: now you read for understanding? Interviewer 2: and you don't re-read as much? CULMI: well, not cause I'm taking this class Interviewer 1: why do you not re-read anymore? CULMI: Because everything is focused now. I don't have a sentence and 'what are you thinking about?' oh thinking about (gestures looking up) Interviewer 1: hmm, so before your mind would wander? CULMI: wander Interviewer 1: so then you would have to re-read? CULMI: yeah, read it and say what'd I read? I don't know. "I don't have to go back too often to rehash words and things like that… And I think I read, read things twice and now I think I read only once--most areas of the book" –KINPE "I'm sitting here and you know instead of going back and reading it again and sometimes three or four times, I'm coming you know, I'm reading it and I understanding it once I'm through with it."-WOLTO "I think I'm reading I'm enjoying it better because before you know, uh, I was reading "blah blah blah blah blah" you know and it seemed to be hell you know but I didn't really with re-reading it and all that, it didn't , uh I didn't so much like it so much. You know, but now with reading it, all the way and not having to re-read it 2 or 3 times, I'm know you, I think it's better." -WOLTO
Communication	"so they give me time to do what I gotta do cause they know how difficult it does with me, and they seen me, used to be, struggling with getting words out, but now it's kinda flowed…it comes out a little better" -PITGL "my brothers told me about that I'm was I'm um, pronouncing words better" –PITGL

Table 14 continued

Category	Examples provided to illustrate perceived change
Activity of Daily Living or Community Activity	DUREV: Well, I go shopping by myself, I mean I went to go get clothes by myself. First time. First time. Interviewer 2: when did you do that? DUREV: about 2 weeks ago, by myself! … DUREV: yeah! I was so happy. Oh, I was so happy. So I feel like I could really go shopping for clothes by myself. You know, I can go to Walgreens and Whole Foods by myself, but going shopping for clothes, I'm ready to go to Macys and every place else! Well, I'm driving. I'm driving, before you know, I used to drive, we used to stop and used to drive, not along Lake Shore Drive but the um, the road… I used to drive around there all the time…with Carol, you know, then I drive off, I drive home, you know but always with Carol… and now, as of yesterday, I was driving by myself. -WOLTO
Confidence or Attitude	"the numbers 1 2 add 3, (softly) 1-2-3, 1-2-3 [referencing an Executive Attention drill] I can can, that gave me a great deal of hope, hope looking at that" -CULMI "Yeah, I feel better, I feel better." -KINPE WOLTO: I consider my change to be reasonably… uh…phenomenal! (laughs) Interviewer 2: (laughs) a reasonable phenomenal WOLTO: yeah, alright. Well, uh, I'm driving. Interviewer 1: And do you think, do feel like the driving is related to being in, having done this study? WOLTO: it probably had a little bit to do with it. If nothing else, it helped me gain more confidence.

Social Validity

Table 15 summarizes indices of social validity derived from post-treatment interviews. Inter-rater reliability, established with a second reviewer who read through and coded interview transcripts for (1) satisfaction (0-10), endorsement of (2) drills, (3) metacognitive strategy training, (4) length of treatment, (5) maze reading, and (6) recommendation of program, was 100%. All six participants rated their satisfaction between 8 and 10, on a scale of 0-10. They endorsed both aspects of the intervention: the drill training and the metacognitive strategy instruction, with comments such as "those drills are very useful to me" (PITGL) and "You can do it, you can do it! I'm telling you, I said it out loud--that's the thing that did it!" (DUREV). Excerpts from post-treatment interviews related to drill and strategy instruction are presented in Appendix C. Participants reported that the six-week length of treatment was appropriate. Two of the participants reported that they would have liked to continue the treatment for longer than the six weeks. Four participants commented that the reading probes were acceptable; two participants did not comment on the maze reading. All six participants indicated that they would recommend the treatment to another person with aphasia.

Table 15

Social Validity of Treatment, Study Procedures, Outcomes

Participant	Satisfaction Rating (0-10)	Endorsed Drill Training	Endorsed Strategy Training	Approved Length of Treatment	Approved Maze Reading Probes	Recommends Program
PITGL	8	yes	yes	yes	No comments	yes
DAVJE	8	yes	yes	yes*	yes	yes
CULMI	10	yes	yes	yes*	yes	yes
KINPE	8	yes	No comments	yes	yes	yes
DUREV	9	yes	yes	yes	No comments	yes
WOLTO	8/9	yes	yes	yes	yes	yes

Note. * = Reported would have liked increased length of treatment

CHAPTER V

DISCUSSION

The goal of this study was to evaluate the efficacy of a six-week intervention combining direct attention training and metacognitive facilitation for improving reading comprehension in individuals with mild aphasia and concomitant reading difficulties. The researcher hypothesized that participants would demonstrate improvements in maze reading associated with the intervention based on a resource allocation model of attention (McNeil et al., 1991). The study also sought to evaluate potential gains on measures of attention, working memory, and resource allocation, as well as potential improvement in reading skills from pre- to post-treatment, to substantiate potential improvements in maze reading performance. Lastly, semi-structured post-treatment interviews were conducted to (1) identify participants' perceived changes that may not have been captured by the repeated measures or standardized testing and (2) evaluate social validity of the intervention and study procedures.

In this chapter, the results of the study are summarized and interpretations of the findings from the multiple baseline evaluation, pre-post treatment assessment, and participant reported data are presented. Treatment and participant variables are explored as potential moderators on remediation effectiveness. The limitations of the current study are also discussed, along with directions for future research.

Maze Reading Data: Efficacy of APT-3

Single case research (SCR), when well designed and executed, can provide strong evidence of treatment efficacy to support evidence-based practices for specific client profiles (Horner et al., 2005; Perdices & Tate, 2009). Replication of effect is an important feature of SCR, as it is a crucial mechanism for reducing threats to internal validity and establishing experimental control. Horner and colleagues propose that "experimental control is demonstrated when the design documents three demonstrations of the experimental effect at three different points in time with a single participant or across different participants" (p. 168, Horner et al., 2005). The current study employed a non-concurrent multiple baseline design, in which six participants were run on three different tiers, or schedules, to allow for up to six demonstrations of effect at three different points in time.

Results indicated a basic effect between six weeks of APT-3 and improved maze reading performance for three of the study's six participants. Visual inspection of the data revealed an improvement in maze accuracy over baseline levels with the introduction of the intervention for the three participants identified as responders (DAVJE, WOLTO, CULMI). Tau-U results corroborated findings identified through visual analysis, as analyses yielded statistically significant results for the three responders. Three of the study participants were identified as non-responders (KINPE, DUREV, PITGL). For these participants, visual analysis did not reveal a relationship between APT-3 and maze reading, and Tau-U analyses did not yield statistically significant results.

Results of the multiple baseline design revealed demonstration of effect (i.e., the predicted change in maze reading co-varied with the APT-3 intervention) for *three* participants at *two* points in time, failing to meet the replication criterion discussed by Horner and colleagues. Therefore, although the data indicate a significant indication of change for three participants based on their maze reading performance, the pattern of the data allowed for by the design make these findings less robust. In addition, results also revealed three demonstrations of non-effect, suggesting that APT-3 did not result in improved maze reading performance for three of the participants.

These findings suggest that the use of APT-3 has the potential to improve reading in this population, but that it may be more efficacious under certain conditions. Treatment and participant variables are offered as potential influences on participants' responsiveness to intervention.

Clinical profiles. Participants' cognitive and reading impairments may influence their responsiveness to APT-3. The cognitive and reading profiles of participants included in previous DAT research are not well specified, particularly with regard to presence of an alexia syndrome (Barker-Collo et al., 2009; Coelho, 2005; Sinotte & Coelho, 2007). Findings from the pilot study raised a number of questions regarding candidacy for implementing APT-3, including severity and type of aphasia, and the influence of specific reading impairment profiles on treatment response (Lee & Sohlberg, 2013). Consequently, inclusion criteria for the current study were narrowed to allow for a more homogeneous sample of individuals with mild anomic aphasia with concomitant cognitive impairments. In addition, measures were added to better characterize participants reading impairments. Performance on reading assessments was consistent with a phonological alexia for four of the participants and surface alexia for one of the participants. Reading performance for one participant did not appear to align with a specified alexia syndrome. Finally, all six participants presented with impairments in attention and/or working memory as measured by performance on standardized cognitive assessments, with impairment defined as one or more standard deviations below the mean on standardized scores for at least one of the measures.

The severity of participants' pre-treatment cognitive and reading deficits is an important variable that may have impacted their responsiveness to the intervention. Figure 5 shows participants' mean baseline maze reading performance and pre-treatment performance (scaled scores) on two measures of attention from the TEA, corresponding to visual attention (top of figure) and resource allocation (bottom of figure). Responders' names are bolded. KINPE and DUREV, both identified as non-responders, stand out from the other participants in terms of their baseline maze reading abilities (represented on the x-axes of the figure). It is plausible that KINPE did not respond to the treatment with improvements in reading due to a ceiling effect. In contrast, DUREV may not have responded because her baseline reading impairments were too severe.

The severity of participants' attention and resource allocation skills also suggests a pattern of responsiveness. For example, PITGL (a non-responder) demonstrated visual attention performance consistent with the sample mean (M = 10), indicating relatively unimpaired attention compared to the other participants, with potentially little improvement to be gained from APT-3 in this domain. Interestingly, PITGL's pre-treatment dual task performance reflects a *greater* degree impairment than the other participants. Whereas a ceiling effect would limit the amount of improvement elicited from the intervention, it could also be the case that a minimum level of skill in a particular domain must be present for optimal response from APT-3. Future research with a larger sample of PWA is critical to address candidacy and systematically investigate the role of severity in responsiveness to APT-3.

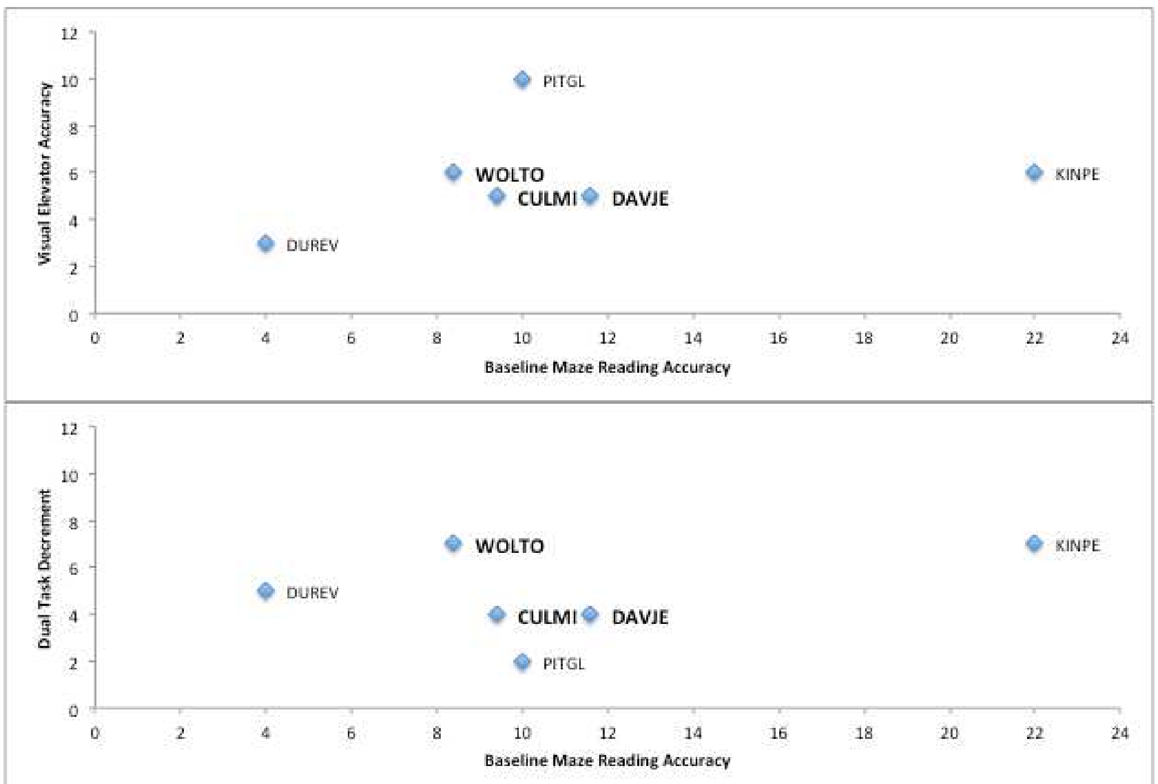

Figure 5

Participants' pre-treatment attention and reading performance

While reading severity appears to impact response to APT-3, there was not a clear pattern of responsiveness based on participants' alexia classification. The three responders presented with alexia, associated with a disruption to either grapheme-to-phoneme correspondence (CULMI, WOLTO) or the semantic system (DAVJE). Two of the non-responders also presented with phonological alexia. Future research involving a larger sample of individuals with various types of alexia syndromes could be helpful in identifying appropriate candidates for APT-3. For example, a stratified sample that included participants with and without phonological alexia would allow for examination of the role of phonological alexia and responsiveness to APT-3. It may be the case that given the additional phonological processing deficits associated with alexia, a boost in cognitive skills is not powerful enough to positively influence text level comprehension. Thus, APT-3 could prove more effective for individuals with attentionally based reading difficulties, without the additional processing deficits characteristic of alexia. It is also plausible, based on the resource allocation theory, that individuals with alexia may benefit *more* from APT-3 than those without because their pool of cognitive resources is compromised by their different sources of reading difficulty.

Treatment intensity. A substantial body of research has indicated that greater amount and intensity of treatment is associated with better outcomes in people with chronic aphasia (e.g., Bhogal et al., 2003; Cherney et al., 2008; Robey, 1998). In the current study, treatment was delivered over a six-week period. In addition to twice weekly clinician-delivered sessions, participants were instructed to complete four independent home practice sessions, for a total of six sessions per week. However, participants completed different amounts of home practice (see Table 7). Therefore, treatment *intensity*, that is the number of sessions completed within the six-week duration, varied between participants. Interestingly, two of the three responders (DAVJE and CULMI) completed more than the requested amount of sessions. However, PITGL, a non-responder, also completed more than the requested number of home sessions. Nonetheless, findings from the dissertation combined with a growing literature documenting the importance of treatment intensity for rehabilitation interventions suggest that intensity is a likely moderator on remediation effectiveness. Future research is needed to identify the optimal treatment dosage of APT-3 to improve reading in individuals with mild aphasia.

Metacognitive strategy usage. Efficacy of APT-3 for improving reading comprehension may be more robust for participants who adopt metacognitive strategy usage within drill practice *and* outside reading activities. A review of literature summarized in the practice guidelines for direct attention training suggests that the inclusion of strategy or metacognitive training, in conjunction with direct attention training, increases treatment effectiveness (Sohlberg et al., 2003). Metacognitive awareness and monitoring of one's comprehension are recognized as critical aspects of the reading process (Guthrie & Wigfield, 1999; Mokhtari & Reichard, 2002). Therefore, metacognitive facilitation is a particularly important element of an intervention directed at improving reading comprehension.

As previously described, individualized strategies were developed and refined throughout the 6-week intervention as exercises increased in difficulty and task demands changed. Participants were encouraged to use their strategies within the APT-3 drill practice. No direct reading or strategy instruction was provided outside of the APT-3 drills, but participants were asked to indicate on reading logs whether or not they used their metacognitive strategies during home reading activities. See Figure 3. Participants largely recorded "yes" to using strategies during home reading. However, their reports of strategy usage during post-treatment interviews were more informative than data extracted from these logs. For example, WOLTO (a responder) described using a preparatory strategy prior to reading at home, as well as an "anticipation" strategy in which he would try to anticipate the stimuli being presented during APT-3 drill practice. Although the "anticipation" strategy was developed during drill practice, WOLTO described applying it to home reading: "I could read something and anticipate some of the words that were coming…and it came…reasonably well then." See Appendix C for full excerpt. Another participant identified as a responder, CULMI, reported using a "focus" strategy during reading and being better able to tune out distractions since participating in the study, whereas KINPE (one of the non-responders) did not comment on strategy usage during his post-treatment interview. It is possible that efficacy of APT-3 is more robust for those participants who actively generalize strategies to their reading activities. Nonetheless, the role of strategy instruction and metacognitive facilitation, on its own and in conjunction with direct attention training, is an area that warrants further exploration with systematic research.

Affective variables. An individual's response to APT-3 may also be influenced by affective variables, such as motivation and self-efficacy. Motivation has been described as an important determinate of rehabilitation outcome for stroke patients (Maclean & Pound, 2000) and individuals with long-term disabilities (Friedrich, Gittler, Halberstadt, Cermak, & Heiller, 1998; Grahn, Ekdahl, & Borgquist, 2000). In a qualitative study using semi-structured interviews, stroke rehabilitation professionals indicated that they attributed patients' motivation to a combination of demeanor and compliance with a treatment regimen (Maclean, Pound, Wolfe, & Rudd, 2000). In the current study, the number of independent home practice sessions completed by participants may be indicative of their motivation. As previously described, two of the responders completed more than the requested home practice. The amount of home reading participants engaged in may also reflect their interest in and motivation to improve reading. The three participants identified as responders (DAVJE, CULMI, WOLTO) reported more home reading than two of the non-responders. See Table 8. It is notable that PITGL (a non-responder) appears to be an outlier, reporting an average of ten hours of reading per week, predominantly spent reading mail and e-mails. It is possible that he either overestimated or over reported the actual amount of reading completed, and so amount of reading did not actually influence his responsiveness to the intervention. As described previously, PITGL may not have responded to APT-3 due to the severity of his resource allocation deficits.

Self-efficacy is a related concept that is believed to influence motivation and participation (Bandura, 1998). According to Dixon and colleagues, who explored perceptions of self-efficacy among adults with neurological impairments, "self-efficacy influences motivation by determining the goals people set, how much effort they invest in achieving those goals, and their resilience when faced with difficulties or failure" (p. 231, 2007). Participants' post-treatment interviews provide anecdotal evidence of participants' beliefs about their capabilities. CULMI, for example, in describing an APT-3 executive attention drill, commented "I can can, that gave me a great deal of hope, hope looking at that." See Table 14. The influence of affective variables, including motivation and self-efficacy, on treatment response certainly warrants further exploration.

Pre- Post-Treatment Assessment Data

The group analyses comparing pre to post-treatment performance on cognitive measures revealed significantly better performance on two of the six cognitive outcomes, i.e., a measure of visual attention/scanning and a working memory span task. Participants did not perform significantly better from pre to post-treatment on the reading assessment. In terms of individual performance, at least half of the participants demonstrated gains on one or more of the measures. However, different participants performed better on different measures, and both maze reading responders and non-responders improved on some measures and not on others. Examination of pre-post assessment data with respect to maze reading and participant reported data led to three hypotheses: (1) given the heterogeneity of this population with differential disruption of brain networks (i.e., no two strokes are the same), and thus differential disruption of cognitive and reading networks, changes might not be expected on the same measures for all of the participants; (2) the selected measures are not sensitive to the improvements that did result from the intervention; or (3) the measures do not tap the cognitive processes targeted by APT-3.

In terms of the first hypothesis, participants in the current study presented with differential impairments on the selected measures at baseline. They also differed on the measures in which they demonstrated improvements. For example, on the CPT-II, only three participants (WOLTO, CULMI, PITGL) demonstrated pre-treatment performance consistent with a "clinical" (i.e., attention deficit disorder) population. Performance post-treatment for these same three participants was consistent with the "nonclinical" population. DAVJE did not demonstrate performance on the CPT-II that was consistent with the clinical sample at baseline, but performed two standard deviations below the mean on the TEA's dual task subtest, suggesting impairment in executive control/resource allocation. Following the intervention, he performed a standard deviation above the mean on this subtest. This pattern suggests that participants with different cognitive profiles may respond differently to APT-3 and perform differently on formal testing. Future research that involves a more homogeneous group of participants with clinical lesion overlap and/or similar neuropsychological profiles could help elucidate this issue.

The second hypothesis asserts that the selected measures may not be sensitive to the improvements that did result from the intervention. This is certainly plausible as several participants noted improvements in concentration, memory, and reading in their post-treatment interviews that are not reflected in their test performance. In addition to interview, future research could employ patient reported outcomes, such as the Communication Confidence Rating Scale for Aphasia (Cherney, Babbitt, Semik, & Heinemann, 2011), that are psychometrically reliable and sensitive to treatment effects. Corroborating participants' perceived improvements post-treatment with reports from family members or caregivers would also strengthen the assertion that improvements resulted from the intervention that were not captured by formal testing.

Lastly, it is possible that not all of the outcome measures tap the cognitive processes targeted by APT-3. For example, three of the six participants demonstrated marginal improvements on the WMS Spatial Span, whereas all six participants demonstrated gains on the PALPA Span task, which incorporates linguistic stimuli. The Spatial Span was selected as an alternative to a typical span task that requires repetition given the language impairments of the population. APT-3 may have actually more directly targeted verbal rather than non-verbal working memory. There are a variety of APT-3 drills that incorporate auditory and visual stimuli. Even the drills employing only visual stimuli (e.g., n-back task with animal stimuli) may be verbally mediated by participants in order to carry out the task successfully. Future research would benefit from outcome measures that closely align with the cognitive domains targeted by APT-3.

Participant Reported Data

There is growing recognition of the utility of patient reported outcomes (PROs) in aphasia, particularly given the current context of Medicare and other insurance agencies seeking outcome measures for clinical care (Irwin, 2012). PROs refer to outcomes reported directly by the patient concerning their overall functioning and sense of wellbeing (Threats, 2012). Interview data are a fruitful source of PROs for people with aphasia who require supported communication and may have difficulty with questionnaires. Semi-structured post-treatment interviews were conducted to explore potential changes that participants attributed to their participation in the study that may not have been captured by the repeated measures or standardized testing. Five domains of perceived changes were identified from participants' comments, including changes related to cognition, reading, communication, activities of daily living (ADLs)/community participation, and confidence/attitude. The researcher facilitated the interviews with open-ended questions, following up the participants' comments with related responses and questions. Therefore, not every category/domain was addressed by every participant. Because of the intervention's focus on executive attention and working memory with hypothesized gains in reading, participants' perceptions of changes related to their cognition and reading were most intriguing.

Perceived cognitive changes. More than half of the participants reported changes in attention and concentration, with comments referring to improved "attention span," "focus" and less distractibility. Likewise, the majority of participants perceived changes related to their memory, with reports of better retention within the APT-3 drill practice and in their everyday lives. (See Table 14.) Interestingly, the four participants who reported perceived improvements in attention also demonstrated improvements on standardized measures of attention, including the CPT-II and the TEA's Map Search. The pre- to post-treatment assessment data does not, however, consistently corroborate participants' reports of improved memory. While all of the participants demonstrated improvements on the PALPA's Span for Noun-Verb Sequences, only one participant, CULMI, demonstrated clinically meaningful improvement on the WMS Spatial Span, a more psychometrically valid measure of working memory. As previously discussed, it is possible that the intervention more directly targeted verbal versus spatial working memory.

Perceived reading changes. Participants identified changes related to reading comprehension, amount of reading, reading selection, and reading behaviors that they attributed to participation in the treatment study.

Reading comprehension. Although participants demonstrated only marginal raw score improvements on the GORT-4 Comprehension index, more than half reported perceived changes in reading comprehension following the treatment. Participants' perception of improvements in reading comprehension did not necessarily correspond to their maze reading performance throughout the intervention. Two of the three participants identified as responders (CULMI & WOLTO) and two of the three non-responders (KINPE & DUREV) commented on improved reading comprehension. See Table 14. There may have been changes in participants' comprehension that were not reflected in the repeated measures or standardized testing.

Amount of reading. Four of the six participants reported reading more as a result of participating in the study. Data from participant reported home reading logs support this finding. As previously described with regard to motivation, the three participants identified as responders (DAVJE, CULMI, WOLTO) reported more home reading throughout the intervention than two of the non-responders. Interestingly, for most of the participants, there was also a trend toward completing more reading as the treatment period progressed. See Table 8. For example, CULMI almost doubled the amount of home reading completed from weeks 1-2 to weeks 5-6 of treatment.

While there may be a pattern in which the treatment responders engage in more reading than the non-responders, it is difficult to draw any causal conclusions about the relationship between the treatment and participant reported reading. It is possible that participants completed more home reading throughout the six weeks of treatment because of cognitive changes associated with engaging in the treatment or perhaps just the discussion of reading during the sessions led to more home reading.

Reading selections. Four participants, three of whom were maze reading responders, also reported changes in their readings selections, including engaging with more challenging material since participating in the treatment. Participants' home reading logs corroborate this perceived change. For example, Table 8 shows that CULMI reported shifting from reading mostly magazines to reading articles from the *New York Times* and the *Chicago Tribune* in the last three weeks of the treatment. Similarly, WOLTO initially reported reading online news reports and progressed to reading an instructional book on boat building by the end of the study. He also reported in his post-treatment interview that this was the first time he was attempting to read an actual book since his stroke. (See excerpt in Table 14.)

Rereading. Participants' report of rereading less since participating in the study was perhaps the most compelling finding to emerge from the post-treatment interviews. Five of the six participants reported a perceive change in this reading behavior. For example, as shown in Table 14, WOLTO describes having to read something “three or four times” before participating in the study and “reading it and understanding it once [he’s] through with it” following the intervention.

There is evidence that supports reduced working memory capacity in PWA, which researchers have linked to their reading difficulties (Caspari et al., 1998; Wright & Shisler, 2005). Therefore, APT-3 tasks were selected with an emphasis on stimulating and enhancing working memory, in addition to executive attention and resource allocation. As hypothesized, the intervention may have resulted in gains in working memory capacity. Although not necessarily reflected in standardized testing, these improvements may have translated into a reduced need for participants to reread in order to comprehend and retain the material.

Social Validity

With regard to social validity within single case research, Horner and colleagues (2005) suggest that intervention procedures be acceptable and feasible, and that both the dependent variable and the magnitude of change in the dependent variable resulting from the intervention have high social importance. The post-treatment exit interviews revealed that participants found the treatment procedures, including various aspects of APT-3 (i.e., drill and strategy training) and length of treatment, acceptable. Eligibility criteria required that participants present with reading difficulties that were a primary concern, establishing improved reading as a socially valuable outcome. Lastly, participants’ reported a variety of changes associated with the intervention that they perceived to be meaningful and important, including but not limited to reading skills.

Study Limitations

Limitations of the current study may help guide the design and execution of future research. First, visual analysis of the multiple baseline data was somewhat compromised because data collection was not continued past a three-week follow up for the first participants to establish stability or extended for the later participants. Doing so would have allowed for vertical analysis of performance between participants and perhaps more convincing demonstration of experimental control. Second, the small sample size and the heterogeneity of etiology, cognitive, and reading abilities of the sample make it difficult to draw conclusions about candidacy and good versus poor responders to APT-3. At the same time, the fact that three participants responded to the intervention with improvements in maze reading despite heterogeneity is supportive of the intervention's external validity. This limitation could be addressed with future single case research or group designs that include greater numbers of participants. In addition, it could be beneficial to stratify participants according to their cognitive (e.g., working memory deficit) and reading profiles (e.g., alexia classification) to improve the representativeness of the sample.

A second limitation of the study relates to the measures employed to characterize the population and evaluate potential changes in cognitive and reading skills. The investigator was cognizant of selecting assessments that were appropriate for PWA. However, the majority of measures were not designed or intended for use with PWA. The linguistic demands of the testing stimuli on the TEA, for example, may have interfered with accurately evaluating participants' attention. In contrast, the PALPA was designed specifically for PWA, but lacks established psychometric properties, limiting the interpretability of findings.

With respect to reading outcomes, the maze task also lacks normative data on adults with aphasia, making it difficult to assess impaired performance or clinically meaningful change. While the validity of maze reading has been established with other reading comprehension assessments, the task may tap more than reading comprehension alone, as successful performance could also be tied to logic or mere guessing.   The GORT-4 was selected as an assessment because it provides a measure of both reading fluency and comprehension and has been applied to PWA in several treatment research studies (e.g., Beeson & Insalaco, 1998; Orjada & Beeson, 2005). While it has strong psychometric properties, there are no normative data on the adult aphasia population. Participants demonstrated marginal improvements in raw scores. However, without standardized scores, it is difficult to draw conclusions on whether their gains were clinically meaningful.

In addition, as identified in the pilot study, it is difficult to draw strong conclusions from the pre to post-assessments. In the pilot work, the researcher suggested that "any changes, in the positive or negative direction, from pre- to posttesting could be a simple regression to the mean of performance variability characteristic of the population" (Lee & Sohlberg, 2013, p. 11). Psychometrically valid and reliable measures are needed to substantiate gains resulting from the intervention. In addition, future research should include a large enough sample to establish adequate power, which is necessary for evaluating statistically significant differences from pre to post-treatment (Field, 2009).

Another limitation of the current study pertains to the interpretability of post-treatment exit interviews. Participants reported perceived changes in community participation and attitude/confidence. Although these changes may have coincided with participation in the study, they may not have resulted from the intervention itself. Aphasia is a socially disabling and isolating condition that drastically disrupts an individual's self-image, relationships, and social roles (Dorze & Brassard, 1995). Therefore, participating in a study that created opportunities for increased interaction with a therapist, involved frequent sessions/visits, and demanded structured home activities could have led to real or perceived benefits independent of the treatment being evaluated. In addition, because the investigator was involved in conducting the interviews, there was potential for experimenter bias. This limitation could be addressed by having a researcher who was not involved in the intervention or study procedures facilitate post-treatment interviews.

Resource Allocation Theory Revisited

The current study has several implications for McNeal and colleagues' (1991) resource allocation theory of attention in aphasia (RAT). RAT is grounded in the premise that the language problems characteristic of PWA may result from or be exacerbated by deficits in attention and working memory, inefficient allocation of resources, or a combination of both. It was hypothesized that APT-3 would improve participants' attention, working memory, and resource allocation/executive control deficits, which would lead to an associated improvement in reading comprehension.

Participants' maze reading performance was, in part, consistent with the RAT, as three of the study's six participants demonstrated improvements in maze reading that co-varied with the six-week intervention. The pre-post assessment data were not fully consistent with the resource allocation model that undergirded the study. It was anticipated that participants would improve in attention, working memory, and executive control or resource allocation as a result of APT-3, and that the measures selected would capture these improvements. As previously suggested, the cognitive assessments may not have been sensitive to the actual improvements that participants made. It is also quite possible that the outcome measures selected did not tap the cognitive domains targeted by APT-3. For example, improvements in participants' resource allocation skills could have resulted from the drill training (e.g., attentional switching tasks), the metacognitive facilitation, or a combination of both. These improvements may have generalized to more effective or efficient reading on the maze task without having been captured by the TEA's Dual Task Decrement, the measure selected to reflect this skill. In contrast to the assessment data, the post-treatment interview data were consistent with the RAT, as participants, including those identified as responders, noted improvements in both cognitive and reading domains that they attributed to participation in the study.

Finally, another possibility worth considering is that APT-3, while designed to target cognitive skills, may have also indirectly enhanced participants' language processing abilities, which may or may not have influenced their reading comprehension. If this is the case, reading improvements associated with the intervention may be explained by traditional models of language activation (e.g., Schuell's stimulation approach (Duffy, 1994)) rather than the resource allocation theory.

Summary and Conclusions

This study evaluated the efficacy of a six-week intervention combining direct attention training and metacognitive facilitation for improving reading comprehension in individuals with mild aphasia. Findings, in part, support previous research demonstrating the potential of direct attention training to improve reading in PWA (Coelho, 2005; Lee & Sohlberg, 2013; Sinotte & Coelho, 2007). The hypothesis that the six-week APT-3 intervention would lead to gains in attention, working memory, and/or resource allocation with subsequent improvements in maze reading, based on resource allocation theory (McNeil et al., 1991), was supported by results from three of the six participants. While additional research is needed to establish the efficacy of APT-3 for improving reading in PWA, this study represents a meaningful contribution to the emerging literature investigating the relationship between attention and language impairment in PWA.

Next Steps

Direct attention training programs often target discreet skills through attention drills that do not resemble functional tasks. Consequently, they have been criticized for not generalizing to skills outside of the treatment tasks (Park, Proulx, & Towers, 1999; Peach, 2012). Results from the current dissertation suggest that APT-3 did generalize to reading improvements for three of the study's six participants. Nonetheless, it is possible that APT-3 could be *more* efficacious for improving reading in PWA if it were provided with reading treatment. Therefore, a promising next step in this line of inquiry is to evaluate the efficacy of APT-3 in conjunction with direct reading intervention. For example, attention training combined with a treatment that targets grapheme-to-phoneme conversion might prove more effective for a PWA with phonological alexia than the reading treatment alone. Another next step is based on findings from the dissertation suggesting that efficacy of APT-3 is more robust for those participants who actively generalize strategies to their reading activities. It would be informative to evaluate the impact of metacognitive strategy instruction on reading comprehension more directly, both on its own and in conjunction with DAT. In addition, future research could examine whether specific strategies are more successfully applied by PWA to reading than others. Together, these next steps point toward an exciting line of inquiry that has the potential to advance rehabilitation outcomes for individuals with aphasia.

APPENDIX A

COGNITIVE, LANGUAGE AND READING ASSESSMENTS

Language Skills Assessments

- Western Aphasia Battery, Aphasia Quotient (WAB AQ), Part 2: Cognitive Quotient, Reading and Writing subtests
- Nonword Reading from the Psycholinguistic Assessments of Language Processing in Aphasia (Kay et al., 1992)
- Spelling-Sound Regularity Reading Task from the Psycholinguistic Assessments of Language Processing in Aphasia (Kay et al., 1992)

Pre-post Treatment Cognitive Skills Assessments

- Conners' Continuous Performance Test-II (CPT-II; Conners, 2000)
- Test of Everyday Attention (TEA; Robertson et al., 1994)
- Spatial Span subtest of the Wechsler Memory Scale-Third Edition (WMS-III; Wechsler, 1997)
- Pointing Span for Noun-Verb Sequences from the Psycholinguistic Assessments of Language Processing in Aphasia (Kay et al., 1992)

Pre-post Treatment Reading Skills Assessment

- Gray Oral Reading Tests-4 (GORT-4; Wiederholt & Bryant, 2001)

APPENDIX B

POST-TREATMENT INTERVIEW GUIDE

1. Since you began participating in the project, have you noticed any changes?

   If so, what are they *(please include both positive and negative changes if applicable)*?

   Please give us some examples?

   (Probe as needed – may be cognitive (i.e., attention/memory) or language (speaking, reading, etc…) related changes; behavioral; psychosocial changes etc.

2. Has anybody else noticed changes?
3. How satisfied were you with the APT-3 treatment in general?

   Why?

   Did the treatment meet your expectations?

4. Would you recommend being involved in this research to a friend?
5. Would you repeat this research project if you could?
6. Do you have any comments about the length of treatment (e.g., practice sessions, practice time per week, 6 weeks of treatment?
7. Do you have any comments about taking the reading probes?
8. What did you think about the computer program?

APPENDIX C

EXCERPTS FROM POST-TREATMENT INTERVIEWS

Participant	Drill Training	Strategy Training	APT-3 general
PITGL	PITGL: if you/ interact with the person/ you you know/ what they need and what they can do and what they can't do INTERVIEWER: mhmm PITGL: cuz just like you you know what I I I I okay we we take this up some more INTERVIEWER: uh huh PITGL: this one we take this out/ we'll do this now a matter of fact you do you do a good/ good good job with that INTERVIEWER: thank you that's good to hear PITGL: you know what I can do and what I couldn't do cuz you know that one gave me a headache you hurry up and got that outta there	yeah it was useful, it its good, but if everybody havin different strategies you know, my strategies might not work for for you, but the next guy, it might work for him	I'm really satisfied PITGL: see everything it don't have like like peoples say I had a stroke/ everybody have a stroke is different/ that's why I'm saying/ that's your job to// evaluate the person INTERVIEWER: mhmm PITGL: that that make sure/ that/ program// for that person
DAVJE	because some of the drills were kind of, I don't know, tricky…strange, little bit, but but those, those drills are very useful to me the memory part um, actually I found that it's more important than you [I] thought	yeah my strategies … refocus, confidence and the…repeat I would say between these, I would refocus and confidence more than anything for sure … and then I'd do repeat but these two for sure, refocus and confidence	It's useful, it's useful
CULMI	I come home and say okay, I can do this tasks every day and I say, lets see what I want to watch on the tv xxxx to do the tasks, shut the tv off for the first time, I focus on the task ok, focus on the task, I didn't worry about tv, didn't worry about going anywhere, I don't worry about getting anything done. Just the task. I thought about it all day long	JL: we used the strategies on those tasks and it also sounded like you used them in your everyday life. CULMI: Yeah, I did the "Focus" she said, "what are your strategies?" I said, "hmm, let me think, I got a look at it, focus, focus"	I don't wanna quit. I love it, love it, love it. All of it.
KINPE	the drills they helped that (memory)	Did not reference in interview	I liked that it was good, uh study, good improvement

	the drills were okay, were good… some were better than others…but generally speaking, they were good I think I got better slightly over the time, knowing that you kept changing them as I changed		while doing it I felt better as I went along and progress in the program
DUREV	well I don't want nothing too easy, you know, but it was going harder as it go up. It's go harder and harder, you know you can start little and then go up and up and up and up and all the way up, just like when I had to see and get …10, 15, 19,18, then you gotta close your eyes and remember or reverse it! And that was a good one.	DUREV: right, you can do it! You can do it! (referencing positive self-talk strategy) INTERVIEWER: And did you use that? DUREV: I said it, I'm telling you INTERVIEWER: When you went to the store? DUREV: I'm telling you, I said it, I said it. Out loud! Oh yeah, you know I get crazy—(louder) I can do it! And everybody like, what you talkin about? I know what I'm talkin about. INTERVIEWER: nice. DUREV: yeah, but that's the thing that did it.	"all of it, all of it, one big thing, all of this helped" "I had fun"

WOLTO	I liked the tasks	WOLTO: then I started doing it and I'd say "oh, this and this seems to help me well" you know, so I I I started doing that as a pre treatment or a pre thing, I'd start and the book would be open and the page or something and I'd sit there and I'd say, you know, "now I gotta do this" Yeah, it it it yeah. JL: so tell us about what strategies you found most helpful and what were you using WOLTO: I I anticipation, you know, where I could read something and anticipate some of the words that were coming, you know, and it came you know it came reasonably well then JL: And that was a strategy that we learned from doing some of those ta— WOLTO: tasks, yeah JL: and then, did you apply it every time you read? WOLTO: I tried to	both of them worked out fairly well"

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