

Efficacy of Attentive Reading with Constrained Summarization-Written treatment in people with
mild aphasia

Jessica A. Obermeyer

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ABSTRACT

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Purpose: The purpose of this study was to evaluate the efficacy of a newly adapted treatment, Attentive Reading with Constrained Summarization-Written, to improve microlinguistic and macrolinguistic aspects of written and spoken discourse of people with mild aphasia.

Background: Attentive Reading with Constrained Summarization-Written takes a top-down approach to language rehabilitation that focuses on the cognitive-linguistic processes required for spoken and written discourse production.

Methods: Five people with mild aphasia received Attentive Reading with Constrained Summarization-Written across two single subject experimentally controlled pre-post treatment design studies.

Results: All participants demonstrated improvement in both written and spoken discourse generalization measures. Improvement in functional communication, and confrontation naming was also observed for some participants.

Conclusions: The results reported in these two studies provide preliminary evidence that Attentive Reading with Constrained Summarization-Written is a viable treatment option to improve both written and spoken discourse in people with mild aphasia. Participants demonstrated different pre-treatment profiles and mechanisms of improvement, which are discussed.

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Chapter 1: Background and Context

Stroke is the leading cause of disability in the United States. Up to 40% of stroke survivors experience aphasia (National Aphasia Organization, 2011). Aphasia is an acquired language disorder that can impact the comprehension and production of written and spoken language (National Aphasia Organization, 2011; Sarno, 1997). As a result of reduced communication abilities, people with aphasia can become socially isolated (Leeds, Meara, & Hobson, 2004) and have difficulty returning to work (Wozniak, et al., 1999). People with mild aphasia often have the potential to return to previous life activities and participation; however, there is a shortage of evidenced-based treatments to address the high level cognitive linguistic impairments and the written and spoken discourse deficits that are typically associated with mild aphasia.

Discourse consists of verbal or written expression that is more than one phrase or sentence. Discourse can be divided into micro- and macro-level, which was described by Kintsch and Van Dijk (1978) in their discourse-processing model. Microstructure is the cohesive interrelationship between individual words and sentences and macrostructure includes the organization of main ideas and relevant information that creates a global level discourse framework. Discourse production requires the interaction of both micro and macrolinguistic processes (Linnik, Bastiaanse, & Höhle, 2016) in addition to non-linguistic cognitive processes (Glosser & Deser, 1991 & 1992). Discourse sampling and discourse outcome measures are well represented in the aphasia literature, but there are very few studies that have attempted to address discourse level language in therapy (Penn, Jones, & Joffe, 1997), especially in relation to written discourse. Many evidenced-based writing treatments for people with aphasia address language at the word level (see Beeson & Rapsack, 2002). While these treatments are essential, they target

persons with moderate-to-severe aphasia and as such do not meet the needs of people with mild aphasia who seek to improve their written language at the discourse level.

Attentive Reading with Constrained Summarization-Written (ARCS-W), the focus of study 1 and study 2 (i.e. Chapters 2 and 3, 4, 5, 6), is a treatment designed to improve the written discourse of people with mild aphasia (Obermeyer & Edmonds, 2016). ARCS-W is an adaptation of Attentive Reading and Constrained Summarization (ARCS; Rogalski & Edmonds, 2008), a treatment that addresses the micro and macrostructure of spoken discourse by targeting the cognitive linguistic underpinnings of discourse production. ARCS recruits attention and intention via reading and summarization while imposing constraints which include 1) no non-specific words, 2) no opinions. According to Rogalski and Edmonds (2008), attention is recruited via summarization of current event news articles, which requires the summarizer to select the most salient information from a segment of the article, ignore unimportant details and then produce a succinct and simplified version of the original text. The constraint of using specific words versus nonspecific words requires intentional word selection, which is an important component of microlinguistic discourse structure and engages the cognitive function of intention via the selection of the most specific words from competing but less specific word options. The “no opinions” constraint focuses at a macrolinguistic level by encouraging topic maintenance (Rogalski & Edmonds, 2008; Rogalski, Edmonds, Daly, & Gardner, 2013).

ARCS-W is an adaptation of ARCS that targets written language. ARCS-W addresses the underlying cognitive components of spoken and written discourse via constrained summarization. Prior to summarization, participants identify and write the most important content words (i.e. key words) in the section of text they have just read. The purpose of this step is to focus attention to specific words and to have participants determine which elements are

essential. The keyword identification step also includes meta-linguistic discussion of the key words the participant selected, compared to those the clinician selected. This step is followed by verbal and written summarization where the participant is prompted to use his/her key words to assist in planning their summary, though the summary is produced independently (i.e. without aid of the clinician). In study one, participants could use their keywords to assist in producing their summary, but in study two keywords were used to plan the summary but then removed when the summary was produced. This change was made to increase the number of opportunities participants had to independently recall, retrieve and produce specific words. After the summary is produced, the participant is prompted to read his/her written summary and determine if their guidelines/constraints have been met and if not, explain why. If constraints are not followed, the participant is given the option of producing the summary again after receiving specific feedback on their performance. This process of reading, writing key words and summarizing segments of the text is repeated until the article is summarized and then the participant reads the entire article again and produces a final summary from memory via speaking and writing.

Like ARCS, ARCS-W taxes the cognitive linguistic functions of attention, intention and memory; however, there is a greater emphasis on the components of executive function due to the addition of writing which provides a tangible product to aid self-monitoring. Underlining and comparing key words assists participants with identifying important information in the text and transforming that information for summarization, which is often difficult for people with aphasia (Ulatowska & Chapman, 1994; Ulatowska, Chapman, Johnson, Branch, 1999).

ARCS-W is a holistic, top-down approach to language rehabilitation that encourages generalization by focusing on the process of discourse production versus the individual linguistic components required to produce discourse. This focus emphasizes the whole text, which is an

important component of the treatment. Research evaluating the written discourse of people with aphasia shows that they spend most of their time revising at the microlinguistic level whereas healthy adults divide their time between revising at the micro and macrolinguistic level (Behrns, Ahlsén, & Wengelin, 2008). A focus on microlinguistics can adversely impact the macrostructure of discourse; therefore, an explicit emphasis on the whole text is made in ARCS-W. Working at a linguistically complex level such as discourse can also provide opportunities for generalization to more simplistic linguistic skills such as confrontation naming (Rogalski et al., 2013) This can occur even though the specific linguistic components are not addressed individually, as they would be in more traditional impairment based treatment approaches (e.g. Boyle & Coelho, 1995; Wambaugh et al., 2001). This hypothesis shares some similarities with the Complexity Account of Treatment Efficacy (Thompson, Shapiro, Kiran, & Sobecks, 2003), which posits generalization to simpler structures along a specific construct (e.g., syntactic structure, typicality) (Kiran & Thompson, 2003; Thompson et al., 2003). ARCS-W does not entirely fit within the CATE framework due to the various potential mechanisms for improvement that may result from ARCS-W (e.g. cognitive skills, microstructure, macrostructure).

Problem Statement

ARCS is a treatment that addresses spoken discourse and the underlying cognitive components of language. ARCS-W, which is based on ARCS, is novel because it targets written language at the discourse level while maintaining an emphasis on spoken discourse and the cognitive skills required for discourse production. ARCS-W takes a multi-modality approach to discourse by targeting both written and spoken summarization and emphasizing self-monitoring. The incorporation of writing allows for greater emphasis on self-monitoring, since revision is

such an integral part of the writing process (see Hayes & Flower, 1980; Hayes, 1996). ARCS-W is innovative because there is a shortage of evidenced based treatments to address the deficits in written and spoken discourse that are associated with mild aphasia. Due to advances in technology writing/typing is becoming a modality used to complete a variety of functional communication tasks (e.g. email, text, social media) and activities of daily living (e.g. banking, shopping) (Beeson, Higginson, & Rising, 2013). The writing treatments that are available typically focus on single word expression and/or spelling (e.g. Beeson, Hirsh & Rewega, 2002; Rapp & Kane, 2002), and typically do not evaluate or target the macrolinguistic and cognitive skills that are required to produce discourse. Therefore, research is warranted to provide evidence of potentially effective treatments that target discourse level written language ability.

Literature Review

Discourse in aphasia. Aphasia is an acquired language disorder that disrupts expressive and receptive language abilities. This can include a spectrum of deficits that range from profound to mild and encompass speaking, listening, reading and writing (National Aphasia Organization, 2011). A variety of treatments are required to meet this range of needs; however, there are very few discourse-level treatments that address speaking or writing (see Boyle, 2011). This creates a gap in the ability to meet the needs of people with mild impairments who are interested in improving their discourse level speaking and or writing ability.

Discourse consists of verbal or written expression that is more than one phrase or sentence and can be divided into micro and macro-level. Kintsch and Van Dijk (1978) defined microlinguistic structure as local level details and the cohesive relationship between words and sentences. Microlinguistic factors typically include word and sentence level abilities such as morphology, phonology, grammaticality, semantic content and more. Although discourse

is defined as output that is greater than one sentence, many researchers attempt to capture discourse by evaluating microlinguistic components only (see Armstrong, 2000; Boyle, 2011). Others have adopted a more holistic approach to discourse analysis that includes micro and macrolinguistic measures (Altman, Goral, & Levy, 2012; Marini, Andreetta, del Tin, & Carlomagno, 2011; Wright & Capilouto, 2012). There is a large evidence base on the microlinguistic aspects of discourse production including lexical retrieval, and sentence production (e.g. Doyle, Goda, & Spencer, 1995; Fergadiotis & Wright, 2011; Rider, Wright, Marshall, & Page, 2008). ARCS-W is an integrated treatment that also targets macrolinguistic elements and the cognitive-linguistic skills required for discourse production; therefore, those elements will be the focus of this literature review.

Macrolinguistic structure was defined by Kintsch and Van Dijk (1978) as the organization of main ideas and relevant information that creates a global level discourse framework. Creating this framework requires the integration of both linguistic and nonlinguistic knowledge to successfully maintain semantic, conceptual and pragmatic organization during discourse (Glosser & Deser, 1992; Van Dijk, 1980). Early studies of aphasia assumed that macrolinguistic skills were largely intact in people with aphasia and that their deficits lied only in the realm of microlinguistics (e.g. Glosser & Deser, 1991). Just as aphasiologists have a better understanding of how cognitive functions/impairments can impact language performance (Erickson, Goldfinger, & LaPointe, 1996; Glosser & Goodglass, 1990; Murray, Holland & Beeson, 1997), there has also been an increase in studies that evaluate macrostructure elements when analyzing the discourse of people with aphasia (Capilouto, Wright, & Wagovich, 2006; Coelho & Flewellyn, 2003; Coelho, Liles, Duffy, Clarkson, & Elia, 1994; Ellis, Henderson, Wright, & Rogalski, 2016). The evaluation of macrostructure has led to conflicts within the

literature due to variations in how elements of macrostructure are defined and the use of different measurement techniques (Armstrong, 2000; Linnik, et al., 2016). For example, Christiansen (1995) evaluated errors of global coherence and Wright, Capilouto and Koutsoftas (2013) evaluated average global coherence. These discrepancies can make results difficult to compare across studies (Ellis, Henderson, Wright, & Rogalski, 2016). Elements of macrostructure that are commonly evaluated in the discourse of people with aphasia include cohesion, local coherence, global coherence, main concepts and story grammar (Armstrong, 2000; Linnik, et al., 2016).

Van Leer and Turkstra (1999) define discourse cohesion as the linking of meaning across sentences. This is typically completed by the use of cohesive markers (Halliday & Hasan, 1976), which are words that inform the listener/reader of information that is elsewhere in the text. Doing this creates a cohesive tie. Cohesive ties are required to completely communicate the desired meaning (Coelho, 1995). Coherence refers to how discourse is organized and can be broken into local and global coherence. Local coherence is the relationship between a sentence/utterance and its preceding utterance while global coherence refers to the relationship between a sentence/utterance and the discourse topic/stimuli (Gloser & Deser 1991, 1992; Wright, et al., 2013). Story grammar is the superstructure or the organization of narrative elements (e.g. setting, coda, etc) (Van Dijk, 1980). Within narratives, main concepts include the most important components of a story or stimuli. In general, the main concepts of discourse represent the “gist” of the stimuli (Nicholas & Brookshire, 1995). These components of macrostructure all contribute to creating the global discourse framework, but each has different non-linguistic cognitive and microlinguistic demands.

Cohesion is often considered the connection between micro and macrolinguistic structure (Armstrong, 2000) because of its interconnection with lexical retrieval (Andreetta & Marini,

2015). People with aphasia commonly use lexically non-specific words such as pronouns and demonstratives without defining a referent (Armstrong, 2000; Glosser & Deser, 1991; Ulatowska, North, & Macaluso-Hayes, 1981), which results in incomplete cohesive ties. Armstrong found that people with aphasia also demonstrate diminished lexical cohesive ties and decreased cohesive harmony (interaction of cohesive elements).

In an effort to better understand coherence, Coelho and Flewellyn (2003) completed a longitudinal study with a person with mild-moderate anomic aphasia over a 12-month period. They found that although microlinguistic skills improved, the person with aphasia continued to demonstrate breakdowns in macrolinguistic structure. The person with aphasia had greater difficulty with global coherence than local coherence. Both measures are macrolinguistic in nature, but have different cognitive-linguistic requirements (Glosser & Deser 1991; Rogalski, et al., 2010). These results add to earlier findings from Coelho et al. (1994) who reported that over a 12-month period a person with mild fluent aphasia improved in sentence level (i.e. microlinguistic) measures (i.e. total number of subordinate clauses divided by total number of T-units) but continued to demonstrate moderately impaired story grammar (i.e. macrostructure).

Wright, Koutsoftas, Fergadiotis, and Capilouto (2010) completed a group study that compared the global coherence of 15 people with aphasia to a group of healthy controls (N=15). They reported that people with aphasia had significantly lower global coherence scores than the control group. Christiansen (1995) took a different approach to evaluating global coherence by analyzing the number of global coherence errors produced by 15 people with aphasia who were categorized into three groups: Anomic aphasia, Conduction aphasia and Wernicke's aphasia. Christiansen (1995) also compared the results of the group with aphasia to a control group (N=20). Global coherence violations were defined as information gaps, repetition of

propositions, and irrelevant propositions. The results revealed that people with aphasia produced more global coherence violations than their aged matched peers. Christiansen hypothesized different mechanisms for global coherence violations based on aphasia type. Specifically, Christiansen concluded that people with anomic aphasia and conduction aphasia had more global coherence errors due breakdowns in lexical retrieval (e.g. omission of propositions) or to the implementation of lexical retrieval strategies that adversely impacted global coherence (e.g. repetition of propositions), while people with Wernicke's aphasia presented with impaired global coherence as a result of irrelevant propositions.

Micro and macrolinguistic skills are intertwined but somewhat dissociable (Glosser & Deser, 1991). Wright and Capilouto (2012) sought to determine the microlinguistic discourse abilities that are required to maintain global coherence in people with aphasia and a control group. Their results revealed that the percent of information units (i.e. words that are accurate, relevant, intelligible, and informative to the stimulus) explained 76% of the variance in global coherence for the control group (N=15) regardless of discourse stimuli. For the group with aphasia (N=15) the microlinguistic variables that predicted global coherence changed depending on stimuli. For one story telling task, the percentage of information units and lexical diversity (i.e. number of different words) explained 85% of the variance in global coherence and for the other story telling task, lexical diversity alone was a predictor of the variance in global coherence (59%). Similarly, Andreetta and Marini (2015) evaluated the correlations between micro and macrolinguistic measures in people with fluent aphasia (N=20). Their findings revealed that the percent of phonological errors were correlated with the percent of cohesion errors ($r=-.528$) and that the percent of semantic word errors were correlated with global coherence errors ($r=-.907$).

These findings demonstrate the importance of taking a holistic approach to discourse

analysis since there are strong relationships between micro and macrolinguistic components of discourse and the non-linguistic cognitive factors that are required to produce discourse (Altman, et al., 2012; Linnik, et al., 2016; Marini et al., 2015; Wright, Koutsoftas, Capilouto, & Fergadiotis, 2014). These studies also highlight the importance of addressing macrolinguistic structure within discourse-level treatments to capture pre-treatment abilities and better understand mechanisms of improvement after treatment. The most recent literature suggests that people with aphasia do indeed demonstrate break downs in their macrolinguistic structure; however, what is not clearly understood is the locus of that impairment (Linnik, et al., 2016; Wright & Capilouto, 2012). The difficulty people with aphasia demonstrate in maintaining macrostructure could be a result of breakdowns in microstructure, a breakdown in macrostructure or a break down in the cognitive linguistic skills required to produce macrostructure. It is most likely that the locus of impairment is different across individuals and potentially across aphasia types as hypothesized by Christiansen (1995). Both micro and macrostructure are essential for discourse production and should be considered during treatment planning and discourse analysis for people with aphasia.

Discourse level treatments. The majority of treatments for people with aphasia address word or sentence level production with few interventions that target language at a discourse level (Boyle, 2011). In recent years, there has been an increase in treatment literature that examines if word and sentence level treatments generalize to discourse production. The results of these endeavors have been mixed, with some treatments demonstrating generalization to discourse (e.g. Edmonds, Mammino, & Ojeda, 2014), while others do not (e.g. Wambaugh, Mauszycki & Wright, 2014).

In keeping with the trend to evaluate discourse outcomes after word and sentence

level treatments, there has been an increase in impairment based treatments that address specific linguistic processes within a discourse context to improve the likelihood of generalization (Boyle, 2011). Many of these treatments have addressed lexical retrieval within discourse contexts such as structured conversation, picture description or barrier tasks. Semantic approaches like Semantic Feature Analysis employed within structured discourse have demonstrated increased proportion (Falconer & Antonucci, 2012; Peach & Reuter, 2010) and number of informative words (correct information units, Nicholas & Brookshire, 1993) (Antonucci, 2009; Falconer & Antonucci, 2012), percent nouns (Antonucci, 2009), percent verbs (Falconer & Antonucci, 2012) and words per t-unit (a main clause and any subordinate clauses (Hunt, 1966)) (Peach & Reuter, 2010). Treatments implementing phonological/orthographic cueing hierarchies within discourse tasks have reported more communicatively appropriate responses in conversation. These improvements were attributed to increased word retrieval (though treated words did not improve in conversation) (Herbert, Best, Hickin, Howard, & Osborne, 2003) and increased content words in unstructured conversation (Greenwood, Grassly, Hickin, & Best, 2010). Peach and Wong (2004) sought to reduce the effects of agrammatism while working at a discourse level. In this approach, the participant listened to fables and then retold them. After the verbal retelling, the participant was asked to listen to each utterance and improve it through writing. The results revealed that this participant had a reduction in grammatical errors and an increase in measures of complexity. Other discourse level treatments have implemented barrier tasks in which discourse can be elicited in a variety of ways, including responding and requesting. Goral and Kempler (2009) reported increases in verb/noun ratio and variety of verbs after a verb focused constraint treatment for someone with nonfluent aphasia. The above studies are a sampling of

discourse level treatments in aphasia, most of which have yielded positive results and promise for increased generalization to functional communication. However, the majority of discourse treatments in aphasia have not included macrolinguistic elements as a focus of treatment or analysis, even though the tasks are reliant on macrolinguistic skills (e.g. structured conversation, story retelling, etc.).

There are also treatments that take a more social/functional approach to discourse production in aphasia that focus more on strategy development and use than impairment. Penn and colleagues (1997) created a hierarchical discourse treatment for a patient with mild aphasia. To do this, they applied a discourse framework developed by Biggs and Collis (1982). The Biggs and Collis (1982) framework of text management includes strategies for problem solving, causal explanations, making judgments about material, conflict resolution, analyzing evidence, and understanding content. This framework was created by analyzing the text of elementary, high school and college students based on Piagetian principles. Penn and colleagues adapted this framework to improve discourse in two people with mild aphasia. The people with aphasia were provided with a variety of different texts including cartoons, magazine articles and were asked discussion based questions about the text (e.g. What is the general content?, Where was this written?). After the treatment, both participants improved on the treated tasks, but no generalization measures were assessed. The authors state that the purpose of this therapy is to compensate for linguistic impairment and reduced flexibility with cognitive strategies and improved meta-linguistic skills.

More recently, Fox, Armstrong and Boles (2009) addressed conversational discourse in a dyad that included a person with mild aphasia and their partner. Intervention goals were based on conversation samples between the dyad and included increasing topic initiation, asking more

questions, etc. Treatment involved fourteen sessions in which the dyad participated in conversation and feedback was given by the clinician. After treatment, listeners rated the partner without aphasia as better at revealing the competency of the person with aphasia. Both the person with aphasia and the person without aphasia rated their conversational interactions higher after treatment; however, fewer changes were observed regarding the specific goals of the person with aphasia and their communication partner.

Like Fox and colleagues (2009), Damico et al. (2015) created a treatment to address conversation in people with aphasia that emphasized conversational shaping. The specific linguistic deficit of word finding difficulty was addressed via self-monitoring of lexical selection and attempts at circumlocution through gestures when word-finding difficulty was encountered. Each treatment session included pre-conversation, intra-conversation and post-conversation components. Pre-conversation involved discussion of the value of conversation in addition to strategies to improve conversation. The Intra-conversational stage was the conversation between the person with aphasia and the clinician in which conversational shaping was used including strategies to address problematic behaviors. The post-conversation stage occurred at the end of each treatment session and involved the person with aphasia and the clinician discussing the conversation goals, strategies, and self-evaluation. After treatment, the person with aphasia decreased the behaviors targeted (e.g. incorrect word recall, and focus on elusive words) and increased strategy use (e.g. lexical self-repair and gestural circumlocution).

These treatments represent a mix of approaches and tasks. The impairment based treatments attempt to improve specific linguistic measures and are more likely to report on generalization. The treatments that attempt to shape discourse and conversation through strategy use typically only report on tasks targeted during treatment with the underlying assumption that

the treatment context itself is functional. However, generalization to unfamiliar partners and environments cannot be taken for granted. There also appears to be a gulf between the linguistic focus of the treatments. The impairment based treatments are more likely to focus on micro-linguistic skills and measures while the functional/social approaches emphasize discourse structure/interaction which would be considered macrolinguistic. One treatment that targets micro and macrolinguistic elements is Attentive Reading with Constrained Summarization (ARCS; Rogalski & Edmonds, 2008; Rogalski, et al., 2013) which is discussed below.

ARCS (Rogalski & Edmonds, 2008) targets micro and macro-levels of spoken discourse as well as cognitive elements that contribute to language such as intention, attention and self-monitoring. Intention is one of the hypothesized mechanisms of Constraint induced language therapy (CILT; Pulvermüller, et al., 2001) and is defined as attention that is focused on selecting and executing a specific action (Crosson, et al., 2007). The current treatment, Attentive Reading with Constrained Summarization-Written (ARCS-W), was adapted from ARCS to address written discourse. The ARCS protocol requires reading with the intent to summarize. Then participants summarize the content while trying to adhere to constraints that address micro and macro-level linguistic processes. The constraints are to avoid non-specific words/pronouns and to not include opinions. Restricting nonspecific words targets micro-level discourse by requiring the intentional selection of more informative, specific words. The constraint of no opinions addresses macro-level discourse by encouraging topic maintenance. In addition, participants must self-monitor and self-evaluate their adherence to these constraints during discourse production.

The intent to summarize and the requirement to follow constraints during summarization are critical to ARCS and ARCS-W. In addition, the primary task of

summarization itself requires the integration of many cognitive and linguistic processes. When producing a summary, a speaker/writer has to comprehend and store information, identify the most salient information, ignore unimportant details, hold information in working memory and then produce the summary in their own words. These processes make summarization more cognitively taxing than other forms of discourse (Chapman, et al., 2002; Doyle, et al., 1998; Ulatowska & Chapman, 1994; Youse & Coelho, 2005).

ARCS was first administered to a person with Primary Progressive Aphasia in a case study (Rogalski & Edmonds, 2008) with the purpose of improving semantic specificity and topic maintenance. The participant with PPA improved his percent of relevant information, coherence and cohesion in discourse. ARCS was then adapted and administered to two people with Wernicke's aphasia (Rogalski, et al., 2013). One of the participants with Wernicke's aphasia increased confrontation naming accuracy and relevant content production within discourse. The other participant did not respond to treatment, potentially due to more severe language impairment pre-treatment, including difficulties with treatment tasks such as oral reading.

ARCS-W further adapts ARCS principles to address discourse level writing in people with mild aphasia while maintaining an emphasis on the cognitive skills required for discourse production and spoken discourse. The addition of written discourse emphasizes error detection and self-monitoring, providing greater opportunity to engage cognitive-linguistic skills. ARCS-W aims to fill a gap in clinical treatment research for paragraph/discourse level writing, since most writing treatments for aphasia target word level written expression (e.g. Beeson & Rapcsak, 2002). While word level treatments are essential for people with moderate to severe aphasia, those with mild aphasia and dysgraphia who seek to regain text writing ability require that

treatment be at a more advanced linguistic level. ARCS-W does not aim to improve the specific linguistic processes required to spell words. Rather, it focuses on the integration of cognitive and linguistic skills required when producing spoken and written discourse.

Written discourse in people with aphasia. Discourse level treatments for aphasia are becoming more and more frequent in an attempt to increase generalization and the impact of treatment on functional communication (Boyle, 2011). Research on the written discourse of people with aphasia, on the other hand, lags far behind spoken discourse especially in relation to treatment. This is problematic since writing and typing are becoming more important to complete activities of daily living, as many of these (e.g. banking, shopping, socializing) are now completed with a keyboard (Dietz, Ball, Griffith, 2011). This evolution also means that writing/typing are more likely to be addressed in speech-language therapy sessions. One reason written discourse has been studied so infrequently could be related to how difficult text writing is for many people with aphasia. When people with aphasia are at the level to address text writing, they have usually been discharged from speech and language services due to mild impairment and/or insurance stipulations (Behrns, et al., 2008). Written discourse production is certainly a niche within the aphasia literature; however, this level of written communication is often required for people with aphasia who plan to return to work or live independently within a culture that is becoming more and more reliant on typing. A multi-modality approach like ARCS-W also allows both spoken and written discourse to be targeted simultaneously in treatment, versus working only on written discourse.

Writing differs from speaking in a variety of ways. One of which is the absence of feedback from a communication partner and the lack of suprasegmental cues such as tone of speech. As a result, writing needs to be more explicit and specific than speaking which impacts

word selection and vocabulary (Behrns, Wengelin, Broberg, & Hartelius, 2009; Gelderen & Oostdam, 2002). Another factor that separates writing from speaking is time and the production of a tangible product. These two factors could be advantageous to people with aphasia because they provide the ability to plan and revise written discourse (Behrns et al., 2009; Freedman-Stern, Ulatowska, Baker, & DeLacoste, 1984). Ulatowska, Hildebrand and Hayes (1978) compared the spoken and written discourse of people with aphasia and a control group and found that people with aphasia produced more errors than controls in written discourse, syntactic complexity was reduced, and that people with aphasia required more time to produce spoken and written discourse. Behrns and colleagues (2009) took a slightly different approach by comparing the spoken and written discourse within people with aphasia. Behrns et al. (2009) found that the written discourse of people with aphasia was more syntactically complex (e.g., clauses per t unit and words per t unit), contained fewer words and had higher lexical density than their spoken discourse. Much of written discourse research has concluded that written text is typically well structured even though specific linguistic breakdowns are prevalent (e.g., sentence structure, word retrieval, etc.) (Behrns et al., 2009; Freedman-Stern, et al., 1984; Ulatowska, et al., 1978).

Behrns et al. (2008) completed a study that compared the revision process in text writing in a group with aphasia (N=8) and a control group (N=10). Writing models (e.g., Hayes & Flower, 1980; Hayes, 1996) suggest that revision is rarely linear and occurs at various stages in the writing process. Interestingly, Behrns and colleagues found that people with aphasia are more likely to spend their time revising single letters and words in attempt to produce the correct target while the control group revised words, clauses and paragraph level text. The authors do not specifically discuss macrolinguistic structure, but these findings illuminate potential problems that can occur when people with aphasia produce written text. The control group spent their time

revising at the text-level to improve both micro and macrostructure; however, the group with aphasia focused more specifically on microlinguistic elements during revision possibly at the expense of macrolinguistic structure.

As might be expected, people with aphasia present with a range of writing abilities; therefore, global conclusions about text writing ability are difficult to make. This is likely one of the reasons that so few text level writing treatments exist for people with aphasia. Given that many single word writing treatments have proven efficacious (e.g., Beeson & Rapcsak, 2002) it is certainly possible that a discourse level writing treatment could also be beneficial for people with mild aphasia. The current treatment, ARCS-W, will primarily focus on discourse level writing with an emphasis on the cognitive skills required to produce discourse both in writing and speaking.

Cognitive requirements of discourse level writing. Cognition is typically defined as having five interrelated but also distinctive domains, which include attention, memory, executive function, language and visuospatial skills. Language is the domain that is most commonly associated with aphasia and aphasia therapy; however, the remaining cognitive processes are gaining greater consideration within aphasia literature as both important predictors for positive treatment outcomes and targets for intervention (e.g. Helm-Estabrooks, 2002; Murray, 1999).

Cognitive functions are recruited to varying extents, depending on the task. For example, completing a maze requires goal directed behavior, planning, self-monitoring (i.e., executive functions), focused attention, visuospatial skills, and potentially language for strategy development. These functions are not recruited to the same degree during a task and each individual may have a slightly different response to a task. This example also illustrates how interconnected cognitive processes are. In fact, many researchers consider high-level forms of

attention (e.g., selective attention, divided attention) to be under the purview of executive functions (Banich & Compton, 2011; Purdy, 2002) while others consider them intertwined but dissociable (Helm-Estabrooks, 2002).

Hayes and Flower (1980) proposed a cognitive model of discourse writing that was later updated by Hayes (1996). The Hayes model includes both environmental and individual factors. The environmental contributions of writing include the social (e.g., audience, collaborators) and physical (e.g., text so far, medium) context. The individual includes motivation (e.g., goals, beliefs), working memory, long term memory, and cognitive processes (e.g., text interpretation, text reflection, text production). The Hayes model incorporates cognitive functions such as working memory into the writing process; however, the model often does not state explicitly what cognitive functions are required during each portion of the writing process. Figure 1.1 includes a schematic of the Hayes model with the addition of the corresponding cognitive demands added to each portion of the model. It should be noted that the Hayes model is a theoretical process model based on writing observation and think aloud tasks (Alamargot & Chanquoy, 2001). The Hayes model does not emphasize the individual cognitive or linguistic functions (e.g., word retrieval, sentence production) of writing, which can make its application to disordered populations complex.

The Task Environment

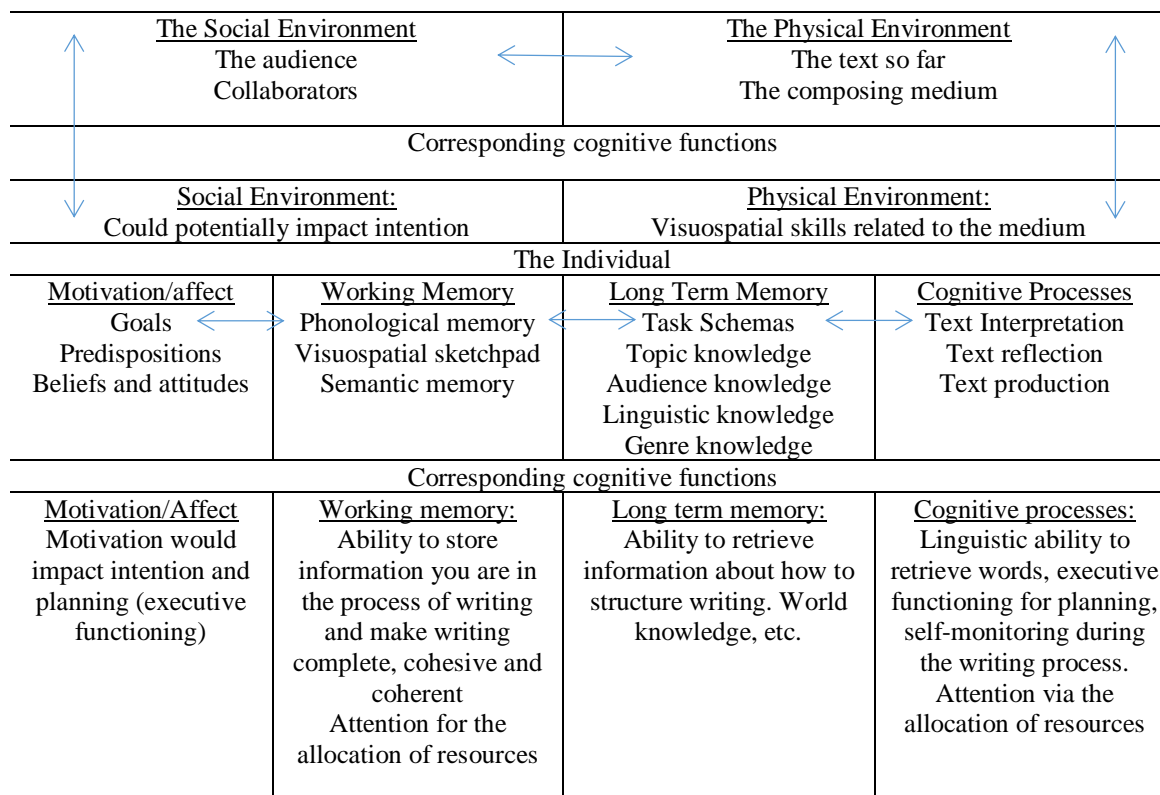


Figure 1.1

Schematic of Hayes model of writing (1996) with the addition of corresponding cognitive requirements

Cognitive components of ARCS-W. The ARCS-W treatment taxes the cognitive linguistic functions of attention and intention like its predecessor ARCS (Rogalski & Edmonds, 2008). There are substantial executive function components required via continuous prompts to self-monitor and organize information and through the addition of writing, which provides more opportunities for self-monitoring. Working memory and short term memory are also required for summarization (in both ARCS and ARCS-W) due to the need to temporarily store, simplify and then produce a summary of the original content. Additionally, ARCS-W is primarily based on written summarization. Text writing is a complex cognitive linguistic process that requires many of the same cognitive functions of spoken discourse; however, there is also potential for varying cognitive demands. The cognitive functions that ARCS-W requires for successful completion and will be discussed individually below. How these skills are related to written text production

and aphasia are all discussed.

Intention. Intention refers to a person's ability to select and initiate a single action among competing actions (Crosson, et. al, 2007). As such, intention mechanisms are associated with frontal action systems (Heilman, Nadeau, & Beversdorf, 2003). Abdullaev and Posner (1998) showed that during language tasks medial frontal brain activity preceded left lateral frontal activity. In addition, Picard and Strick (1996) found that pre-supplementary motor cortex (SMA) is activated during both complex hand movements and word generation tasks. Further, Crosson et al. (2005, 2007) found that there was overlap of the pre SMA area activated during word generation and complex hand movements. These findings support the importance of the medial frontal cortex's involvement in word generation, as well as intention.

The importance of intention for language relates to the number of options (i.e. words) that are available to communicate an idea (Crosson, 2008). For example, when referring to a spouse in conversation you could use any of the following words: partner, significant other, spouse, husband/wife, or his/her name. Selecting and initiating the action to produce one of those words, requires intention.

Crosson and colleagues (2005) consider nonfluent aphasias to be disorders of intention because of the difficulty that people with nonfluent aphasia have with word selection and initiation. Intentional language use is considered to be one of the driving forces of improvement in Constraint Induced Language Treatment (Pulvermüller, et al., 2001). Although the mechanisms for this improvement are not completely understood, Pulvermüller and colleagues hypothesized that by constraining people with aphasia to use spoken language, they are overcoming nonuse via intentional language use.

ARCS-W addresses intention by requiring participants to include specific words in their

summaries via the constraint “only use specific words”. The intentional selection of specific words opposed to non-specific words such as pronouns (e.g., thing, he, etc.) or uninformative words (e.g., stuff) has the potential to impact the informativeness of communication for people with aphasia and requires people with aphasia to exercise self-monitoring of their word selection.

Attention. Attention is a complex cognitive function that can be broken into different types and is widely dispersed throughout the brain. While intention is related to action and frontal lobe processes, attention, at its most simplistic level, is related to sensory processes that occur in the posterior regions of the brain (Crosson, 2008; Heilman, Watson, & Valenstein, 2003). Attention refers to the ability to focus on one of many competing stimuli in need of cognitive processing. Attention can also be considered in terms of alertness, which refers the ability to select stimuli and respond to it. Alertness can be low when someone is tired or in extreme cases, in a coma (Banich & Compton, 2011). This level of attention is required to complete the majority to tasks. Focused attention is a person’s ability to maintain alertness of vigilance for an extended period and has been associated with right inferior parietal brain regions, right frontal lobe, thalamus and brain stem (Peterson & Posner, 2012). For the purposes of this study, the more high-level forms of attention (e.g., selective attention, divided attention) are the most relevant because the participants involved in this study will be mildly impaired and likely have relatively intact levels of alertness.

High-level attention refers to selective attention, and divided attention. Divided and selective attention are often considered executive functions, but will be discussed under attention for the purposes of this paper. Selective attention refers to a person’s ability to attend to relevant information and to “ignore” information that is not required. Lastly, divided attention is the ability of a person to attend to more than one task at a time. Both selective and divided attention

are associated with the prefrontal cortex (Banich & Compton, 2011). Peterson and Posner (2012) report that the cingulo-opercular network of attention is important for maintaining attention during a task and the fronto-parietal system is involved in switching attention.

The most prevalent theory of attention posits it as a limited capacity system; therefore, there are a finite number of attentional resources that other cognitive functions compete for (Navon & Gopher, 1979; Wickens, 1991). Capacity limited theories operate under two assumptions: the attentional system consists of a quantitatively limited amount of attentional resources and those resources can be used to complete more than one activity at a time by flexibly allocating resources. The allocation of attentional resources can be impacted by novelty, intent, and arousal level. While this is not the only theory of attention (Corbetta & Shulman, 2002; Posner & Rothbart, 2007), it is the one most commonly adopted by aphasiologists (Murray, 1999).

McNeil and colleagues (e.g., McNeil, Odell, Tseng, 1991; McNeil, 1983; Tseng, McNeil, & Milenkovic, 1993) were some of the first to propose the theory that impairment of attention could impact the linguistic performance of people with aphasia. Evidence for attentional interaction affecting linguistic performance includes the variability that is demonstrated within subjects. In addition, people with aphasia demonstrate context effects based on non-linguistic changes in the environment (e.g., background noise, presentation rate) (McNeil, et al., 1991; Murray, 1999; Tseng, et al., 1993). Dual task studies provide most of the research support for attentional theories related to aphasia. Dual task studies require participants to perform a linguistic task alone and in competition with another task (may or may not be linguistic). Based on a resource allocation model, determining the effect of each task on the other provides evidence of how much each task competes for the same resources (Murray, 1999) This theory

has been supported in many studies in which people with aphasia demonstrate greater dual task effects than neuro-typical controls in a variety of dual task conditions (Murray, 2000; Murray, Holland, & Beeson, 1997). Murray and colleagues reported that increased attentional demands resulted in decreased word retrieval accuracy in phrase completion tasks (Murray, 2000), and during narrative discourse (Murray, Holland, & Beeson, 1998) in people with aphasia.

No studies were found that examined attention and writing in people with aphasia. Based on a resource allocation model of attention, all written and spoken discourse production require resources and the more difficult/complex the task, the more resources are required. Additionally, there is research that has examined attention and other cognitive linguistic functions in regard to written text production in developing writers with attention deficit and hyperactivity disorder (ADHD). These studies have typically found that young writers with ADHD produce fewer words in written discourse, have reduced word complexity, reduced planning and reduced general writing ability (De La Paz, 2001; Resta & Eliot, 1994; Ross, Poidevant, & Miner, 1995). These results provide evidence that reduced attention and executive functions, which are characteristics of ADHD, impact written discourse abilities in developing writers at a micro and macrolinguistic level.

ARCS-W requires complex attention at multiple stages. Attention is required for all discourse production, but for the ARCS-W treatment it is specifically recruited during the key word identification stage to identify the words that should be focused on during summarization. Additionally, ARCS-W requires frequent shifts in attention from speaking and writing/typing and focused attention to listen/read articles.

Verbal short-term memory and working memory. Working memory refers to the ability to simultaneously process and store information while it is being updated and manipulated to

complete a cognitive task (e.g., mentally calculating how much a new bicycle would be if it were 20% off) (Baddeley, 2003). Verbal short-term memory can be considered a component of working memory and refers to the short-term storage of verbal information (Minkina, Rosenberg, Kalinyak-Fliszar, & Martin, 2017) which is hypothesized to be active during language processing and word retrieval (Martin & Saffran, 1997). Working memory has been localized to the prefrontal cortex, and primarily the dorsal lateral prefrontal cortex (Funahashi, 2006), although many working memory tasks often rely on brain activation throughout the prefrontal cortex (e.g., N-back task) (Banich & Compton, 2011; Wager & Smith, 2003). Recent research also suggests that the dorsal lateral prefrontal cortex is specifically related to the manipulation or selection of information, while the storage function of working memory is more likely completed in the left temporoparietal region (Postle, Druzgal & D'Esposito, 2003).

There are many theories of working memory (Baddeley & Hitch, 1974; Cowan, 1988). One of the most common in cognitive and linguistic literature was proposed by Baddeley and Hitch and has been updated (Baddeley, 2000) to reflect new findings regarding working memory and other cognitive processes. Baddeley's theory of working memory has four components: the phonological loop, the visuospatial sketchpad, the central executive and the episodic buffer. The phonological loop is short-term storage that includes the phonological input store and the articulatory rehearsal process. The visuospatial sketchpad holds and manipulates both visual and spatial information. The episodic buffer was added to the model (Baddeley, 2000) as a storage system that acted as a go-between for working memory (i.e., phonological loop and visuospatial sketchpad) and long-term memory. This function belonged to the central executive in Baddeley and Hitch's original model (1976); however, the central executive's role has changed throughout iterations of Baddeley's working memory model. In its current state the central executive is

responsible for the allocation of attention to complete working memory tasks. Based on this model working memory and attention are highly interconnected. Without the allocation of attention from the central executive, no working memory task could be completed.

Researchers have tried to understand the working memory ability of people with aphasia, especially in regard to the phonological loop, through a variety of assessments (Christensen & Wright, 2010; Mayer & Murray, 2012). The majority of these studies have revealed that people with aphasia have impaired working memory systems when compared to neuro-typical controls (Christensen & Wright, 2012; Gutbrod, Cohen, Mager, & Meier, 1989; Mayer & Murray, 2012) and that some of their linguistic impairment is related to working memory capacity (Wright & Fergadiotis, 2012). Interpretation of these results can be difficult given the highly linguistic nature that most working memory tasks have. Even working memory tasks with limited verbal speech required often involve linguistic rehearsal or other linguistic strategies (Christensen & Wright, 2012; Wright & Fergadiotis, 2012). Other researchers theorize that cognitive functions such as verbal short term memory do not just interact with language but are cognitive requirements for language and are therefore completely intertwined (Minkina, et al., 2017).

Writing theories acknowledge the importance of working memory in the production of written discourse (Hayes, 1996; Kellogg, 1996). However, the exact nature and extent of working memory's role is seldom clear in these models. Kellogg identifies working memory as an important factor in the planning, execution and revision stages of writing; however, writing is seldom such a linear process and therefore, working memory requirements are likely to wax and wane during text writing. Both the Hayes and Kellogg models agree all the components of the Baddeley and Hitch (1976) model of working memory are active during the writing process. For example, the phonological loop would be active in the writing process (i.e., rehearsing what you

are in the process of writing), and the central executive is required to modulate other cognitive functions required during writing while the visuospatial sketchpad can be used during planning and text writing/revision. Written discourse production is more time intensive than spoken discourse. As such, there is the potential for a heavier working memory load for text in planning (i.e., future text), but less load for the text that is already written since it is recorded (versus spoken discourse).

ARCS-W addresses/requires working memory and verbal short term memory through temporary storage and summarization. To summarize an article during treatment, people with aphasia must store important information within short term memory and manipulate that information via working memory to produce a summary in their own words. While the ARCS-W pilot study (study 1, Chapter 2) attempted to reduce the working memory component of the treatment by allowing people with aphasia to use key words when summarizing, the dissertation study (Chapter 3, 4, 5, 6) required summaries to be produced independently (without key words). This change was made to increase the memory load and increase the likelihood of generalization.

Executive functioning. According to Baddeley (1996), executive functions are involved in controlling higher order cognitive processes. This includes switching cognitive set, monitoring performance or other incoming information, selectively attending to specific stimuli while ignoring distracting ones, and organizing multiple tasks. Executive functions are especially important for completing complex and novel tasks in a flexible manner (Purdy, 2002). Executive functioning includes high-level and very interconnected cognitive processes that require other cognitive processes to complete. For that reason, processes such as working memory and attention shifting are often included as executive functions, while other researchers view executive function and working memory as two sides of the same coin (Hazy, Frank, & O'Reilly,

2006). These skills are no doubt required to complete high level and novel cognitive tasks (Frankel, Penn, & Ormond-Brown, 2007; Purdy, 2002; Ramsberger, 2005).

The brain areas implicated in executive functioning include the prefrontal cortex (PFC) and the areas of subcortex that are connected to the PFC. The localization of executive functions can be problematic, though and a review of lesion data completed by Alvarez and Emory (2006) states that it is more likely that executive functions recruit diffuse brain areas. Tasks designed to measure executive function (e.g. Wisconsin Card Sorting Test, Tower of London) are cognitively complex and therefore require the participation and coordination of varied brain regions. While the frontal lobe may be primarily implicated in completion of these tasks, it also depends on other regions to complete high-level cognitive tasks (Alvarez & Emory, 2006). Hazy, et al. (2006) have proposed a model that relies heavily on the basal ganglia in addition to the prefrontal cortex for the activation of executive functions. Lesion reports also provide evidence that white matter damage has been associated with decreased executive functioning skills (Banich & Compton, 2011). These reports help to elucidate the complexities of executive function. From a practical standpoint, it seems intuitive that such complex cognitive functions would be widely distributed in the brain.

Ramsberger (2005) made a case that executive function ability in people with aphasia has a large impact on their functional communication skills, especially during conversation (Frankel, et al., 2007; Purdy, 2002; Ramsberger, 2005). For example, Ramsberger (2005) reported several behaviors that appeared to be more related to nonlinguistic cognitive behaviors than to language impairment itself during the conversations of people with aphasia. Examples of these behaviors included reduced conversational flexibility and attention switching during conversation. In addition, Ramsberger reported that out of nine measures of executive function that they

completed with people with aphasia, eight of those measures were significantly correlated to conversational success. Purdy, Duffy and Coelho (1994) examined cognitive flexibility in fifteen people with aphasia and found that after acquiring a set of symbols in two of three modalities, people with aphasia were often unable to switch modality when verbal expression failed. Similar results were discussed by Ramsberger, who pointed out that people with aphasia who are most successful in conversation can switch between modality easily and do not limit their conversation to a linear structure. These findings support the interconnection of executive function and spoken discourse in people with aphasia.

There is limited to no research that has explored executive functions as they relate to discourse writing in people with aphasia; however, the importance of executive functioning for writing has been demonstrated in neuro-typical writers and writing models often take executive functioning into account. The Hayes and Flower (1980) and Hayes (1996) models of cognitive processes in writing attribute the monitoring of planning, translating and revising to executive functioning skills. Additionally, the planning involved in discourse writing requires executive function mediation. The literature surrounding developing writers has also demonstrated the importance of executive function in successful writing (Altemeier, Jones, Abbott, & Berninger, 2006; Berninger, et al., 2006; Hooper, Swartz, Wakely, de Druif & Montgomery, 2002).

Altemeier and colleagues (2006) investigated the functions of reading and note taking and found that executive functions provide unique contributions to this dual process versus reading and writing alone. Taking notes on material required the executive function of inhibition while using notes to compose a report was related to verbal fluency abilities. These findings are important for the current project because ARCS-W also requires note taking of key words and then summarization using the key words. In addition, this study highlights that executive functions are

composed of a variety of cognitive functions that can be taxed more or less by specific tasks.

The ARCS-W treatment is highly dependent on executive functioning due to its emphasis on self-monitoring, planning, topic maintenance and switching between modalities. Text writing is unique from spoken discourse because of the revision component. By adapting ARCS-W to writing, it has allowed for more opportunities to focus on self-monitoring. By having people with aphasia examine their written discourse, they can identify if they were successful following the prescribed ARCS-W constraints in a more tangible way that has the potential to improve their self-monitoring within spoken discourse as well. In the ARCS-W pilot study (study one, Chapter 2), participants summarized article segments with the use of their keywords; however, in the current iteration (Chapter 3, 4, 5, 6), participants were instructed to use their key words to plan their summary and then produce it independently (i.e. without key words visible). This additional step emphasizes the executive function of planning and goal directed behavior.

Cognition in spoken discourse. Spoken discourse production also requires the interaction of both linguistic and non-linguistic cognitive processes, especially at the macrolinguistic level. Glosser and Deser (1992) found that healthy older participants demonstrated significantly lower global coherence scores when compared to younger participants. They hypothesized that this finding was a result of age related cognitive decline in the areas of working memory, long-term memory and executive skills. Several other studies have made claims that discourse macrostructure is influenced by non-linguistic cognitive functions (Coelho, et al., 1994; Glosser & Deser, 1991). Rogalski and colleagues (2010) sought to empirically answer this question by evaluating global and local coherence (both discourse macrostructure) in a dual task condition with mobility impaired stroke survivors. Their findings revealed that dual task did not impact local or global coherence in discourse but that the stroke survivors had significantly lower

global coherence than local coherence and that global, not local coherence, strongly correlated with cognitive measures. They reported strong correlations between global coherence and measures of attention and processing speed, specifically, digit symbol substitution and digit symbol copy tasks. One of the suggestions provided for interpreting these findings was that global coherence requires more cognitive resources than local coherence. Wright, Koutsoftas, Capilouto and Fegadiotis (2014) evaluated the correlations between cognitive functions and global coherence in a group of younger adults (i.e., 20-39 years old) and a group of older adults (i.e., 70-87 years old). They found that episodic memory and selective attention had a positive relationship with maintenance of global coherence.

Wright, Capilouto, Srinivasan, and Fegadiotis (2011) also sought to evaluate the relationship between cognitive skills and ability to convey story propositions/story grammar in discourse tasks. They found that episodic memory was positively correlated with completeness in discourse tasks for older adults but not for the younger adults. Youse and Coelho (2005) reported that there was a greater correlation between complete episodes and working memory skills in a story retelling task versus a story generation task. They hypothesize that this was due to the higher cognitive load required for story retelling (i.e. ability to comprehend, store, and then reproduce a story).

In regard to spoken discourse and executive functions, Ramsberger (2005) pointed out how highly interconnected executive functions are to conversational success in people with aphasia. This success is related to cognitive flexibility, problem solving, goal oriented behavior and other higher cortical functions. These findings elucidate some of the connections between cognitive and linguistic functions; however, the inconsistency throughout the literature can make findings difficult to interpret.

The link between macrolinguistic structure and non-linguistic cognitive processes has long been hypothesized (Glosser & Deser, 1991; 1992). Conversely, microlinguistic skills are not typically associated with cognitive processes, although there is evidence to suggest that non-linguistic cognitive skills do play a role in the execution of microlinguistic functions. For example, healthy older people can demonstrate reduced microlinguistic skills (e.g. smaller variety of words, greater number of indefinite words, reduced percentage of information units) in constrained discourse tasks (Capilouto, Wright, & Wagovich, 2005; Cooper, 1990; Ulatowska, Hayashi, Cannito, & Fleming, 1986). These findings have been attributed to age related cognitive changes. There is also a variety of literature to support the importance of verbal short term memory for word processing and production (see Martin & Saffran, 1997; Minkina, et al., 2017) in people with aphasia.

Interactions between discourse and non-linguistic cognitive skills. As previously mentioned, ARCS-W requires discourse production and the cognitive requirements of discourse production. The interconnectedness of these systems is dynamic and poorly understood. To demonstrate, a visual depiction of the interaction between microlinguistic, macrolinguistic and cognitive functions is mapped out below (Figure 1.2). While the relationships between these functions are not understood, existing hypotheses and evidence will be discussed below.

The impact of microlinguistic skills on macrolinguistic structure seems both clinically and theoretically plausible, yet there is only minimal empirical evidence that attempts to describe these relationships. Wright and Capilouto (2012) evaluated the correlations between microlinguistic measures (e.g. percentage of information units, lexical diversity, and syntactic complexity) on global coherence in a group of 15 people with aphasia and a control group (N=15). Their findings revealed that percent of information units was a predictor of global

coherence in the control group and that percentage of information units and lexical diversity were predictors of global coherence in the group of people with aphasia, but to differing degrees based on the stimuli. These findings indicate that the relevant content produced and the diversity of words retrieved was positively related to ability to maintain topic (i.e. global coherence). Additionally, Christiansen (1995) hypothesized that word retrieval was related to global coherence and Armstrong (2000) has tied cohesion to word retrieval. These findings begin to illuminate a very interconnected picture of micro and macrolinguistic structure. Word retrieval is required for sentence production which also requires the ability to produce a sentence frame. These skills are also needed to produce coherent, well-structured and complete discourse (i.e. macro-structure). Disruption in any of these microlinguistic components could adversely impact macrolinguistic structure. However, we also know that these items can be somewhat separated because many researchers have found that people with aphasia have relatively intact macrostructure (Glosser & Deser 1991; Ulatowska, Chapman, Johnson, & Branch, 1999) in light of impaired microstructure. Capilouto, Wright and Wagovich (2005) also found that older adults produced significantly smaller proportion of information units, which evaluate relevant content, when compared to a group of young adults; however, they produced the same number of main concepts indicating that discourse was equally complete.

Additionally, macro-structure could impact micro-structure. Andreetta and Marini (2015) state that retrieving words within a specific discourse framework or context can impact lexical information that is carried throughout an utterance. For example, during storytelling, the discourse context could impact the selection of lexical items. Marini and Urgesi (2012) reported that providing repetitive Transcranial Magnetic Stimulation (TMS) over the inferior frontal gyrus in a group of healthy adults resulted in diminished informativeness and global coherence, while

it is not known how these two measures impacted each other, this finding does suggest their interconnectedness.

The relationship between macrostructure and non-linguistic cognitive skills is similar to the relationship between macrostructure and microstructure. The different components of macrostructure rely on non-linguistic cognitive components to different degrees, and this can also vary based on discourse type (Wright, et al., 2014). For example, complete episodes and main concepts have been correlated with working memory and episodic memory (Youse & Coelho, 2005; Wright, Capilouto, Srinivasan, & Fergadiotis, 2011). Maintenance of global coherence is correlated with selective attention (Rogalski et al., 2010; Wright et al., 2014), processing time (Rogalski, et al., 2010) and episodic memory (Wright et al., 2014). Local coherence was also evaluated by Rogalski and colleagues but it was not correlated with non-linguistic cognitive functions. One explanation provided by the researchers was that maintaining local coherence could be less dependent on cognitive resources than measures such as global coherence (Rogalski et al., 2010).

Macro-linguistic structure benefits from the input on non-linguistic cognitive processes, but language can also be perceived as impacting cognitive functions. One example of this would be complex problem solving and reasoning skills which can rely heavily on both cognitive and language functions. Language can also be used to improve cognitive performance through strategies such as repetition.

Microlinguistic structure includes individual words and sentences in addition to the relationship between words within a sentence (Kintsch, & Van Dijk, 1978). This includes functions such as word retrieval, sentence production and sentence structure. Microlinguistic structure is not typically associated with non-linguistic cognitive function, but there is an

increasing body of literature that supports connections between the two. Murray (2000) has reported that attention impacts word retrieval and McNeil and colleagues (McNeil, 1983; McNeil, et al., 1991) hypothesize that breakdowns in attention cause many of the impairments observed in aphasia (e.g., variability in linguistic performance). Additionally, there is increasing evidence that word processing and retrieval are dependent on verbal short term memory (Martin & Saffran, 1997; Minkina et al., 2007).

Based on these findings, there is strong evidence to support the existence of relationships between language and cognition. What is poorly understood is the nature of those relationships, which are dynamic. Different language tasks require different non-linguistic cognitive functions and require them to different degrees. In healthy adults, studies often do not report a relationship between discourse production and non-linguistic cognitive functions (see Glosser & Deser, 1992; Wright et al., 2014), indicating that the two systems work together seamlessly with minimal effort observed. However, when one portion of the system is not working optimally, the connections and breakdowns are observed more clearly. Evidence for this claim has been demonstrated when comparing the discourse of healthy older and younger adults. Older adults demonstrate reduced micro and macrolinguistic structure, which is suspected to be a result of cognitive changes associated with aging (see Chapman et al, 2002; Glosser & Deser, 1992; Ulatowska, et al., 1986; Wright et al., 2011; Wright et al., 2014)

Evidence of the relationship between text writing and cognition is largely absent in the aphasia literature; however, it is likely that written text would require similar cognitive linguistic functions as spoken discourse. However, writing provides the opportunity self-monitor and evaluate output, which is difficult during spoken discourse production. In fact, revision is a form of self-monitoring that occurs throughout the writing process.

In conclusion, language and non-linguistic cognitive skills are extremely intertwined. Even cognitive tasks that are meant to be nonlinguistic in nature often require linguistic rehearsal or other types of language-based strategies (e.g., categorization) (Christensen & Wright, 2010). Additionally, the completion of language tasks also requires non-linguistic cognitive resources. The result is that the two systems are linked and only certain components can be isolated. The process of writing is a complex task, which makes it likely to be disrupted after brain damage (Papathanasiou & Csefalvay, 2013). The complexity of discourse writing indicates that it requires more resources than tasks that are less cognitively and/or linguistically demanding (e.g., McNeil, 1983; McNeil, et al., 1991; Tseng, et al., 1993), and has implications for the current treatment in relation to participant selection and generalization.

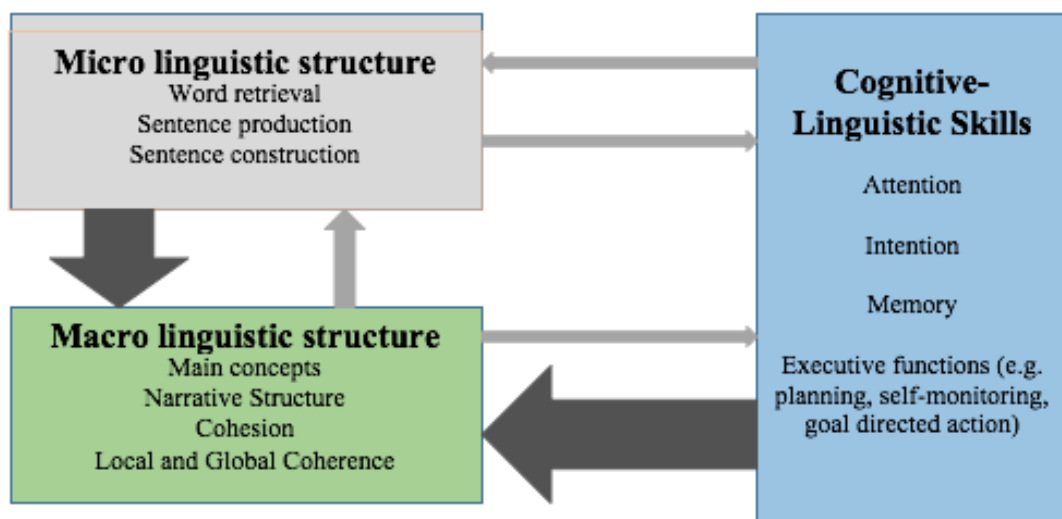


Figure 1.2. Model of the microlinguistic, macrolinguistic and non-linguistic cognitive interactions that occur during discourse production.

Note. Larger and darker arrows indicate greater knowledge and evidence from the literature for those relationships.

Attentive Reading with Constrained Summarization-Written treatment. ARCS-W is a cognitive linguistic treatment that aims to improve discourse level writing and speaking in

people with mild aphasia. In contrast to many language and cognitive treatment approaches, ARCS-W takes a top-down approach to rehabilitation, which emphasizes the interconnected nature of language and cognition. There is evidence that top down approaches encourage generalization to simpler tasks (e.g., Kiran & Thompson, 2003; Thompson & Shapiro, 2007; Rogalski & Edmonds, 2008; Rogalski, et al., 2013). This was demonstrated by Rogalski et al. (2013) when a participant with Wernicke's aphasia improved their confrontation naming ability after receiving ARCS, a discourse level treatment. Theoretically, it is also possible that a discourse level treatment would improve the non-linguistic cognitive functions that are required to produce written and spoken discourse. The cognitive processes that are hypothesized to be most important for successful completion of ARCS-W include intention, attention, verbal short term memory, working memory and executive function. While, these cognitive components are not specifically addressed in treatment, improvement in these areas would likely result in improved success completing the ARCS-W treatment and producing untrained spoken and written discourse. Each of these processes was discussed individually above; however, in reality, they are highly interconnected and dependent on each other to function optimally.

The primary task in ARCS-W is summarization. Summarization is a unique form of discourse because it is more cognitively taxing than other types (e.g., storytelling, picture description). When producing a summary, a speaker/writer has to comprehend and store information, identify the most salient information, ignore unimportant details, hold information in working memory and then produce the summary in their own words (e.g., Doyle, et al, 2008). This process is dependent on attention, working memory and executive functions such as planning, self-monitoring, and goal directed behavior. Below, the steps of the ARCS-W are listed in addition to the non-linguistic processes that are hypothesized to take place during each step.

Table 1.1
Steps of ARCS-W Treatment and Cognitive-Linguistic Skills Required at Each Step

Step	Clinician action	Participant action	Non-linguistic cognitive processes
Step 1	First, the clinician reads the entire article aloud to the participant	Then the participant reads a 1-3 sentence segment, twice for comprehension	Focused and selective attention, verbal short term memory
Step 2	Write down important key words from the segment	Identify and write down important key words from the segment	Selective and divided attention to identify key words and then write or type them, working memory to store key words while writing/typing, executive function via planning to determine what the most important information in the text is.
Step 3	Provide feedback on the key words identified	Compare key words with the clinician's	Divided attention, Executive functions to complete the meta-linguistic task of comparing and contrasting lists of key words.
Step 4	Instruct the participant to plan their summary using key words	Participant will use key words to plan what they would like to say in their summary	Working memory for rehearsal during planning, intention to select desired words, attention for focus to desired information, executive function for planning.
Step 4	Clinician will provide feedback regarding constraints, and content (keywords)	Verbally summarize the segment without use of the key words, while following constraints	Intention to select specific words during summary, working memory to hold required information in the phonological loop while producing summary, executive function to produce summary following constraints.
Step 5	Clinician will provide feedback regarding constraints and content.	Summarize what they read/heard in writing and then read it to the clinician and check for errors	Intention to select specific words during summary, working memory to hold required information in the phonological loop while producing summary, executive function to plan summary following constraints.
Step 6	Repeat steps 2-5 until each segment of the article has been summarized		Repeated
Step 7		Listen to/read the entire article	Focused and selective attention, potentially working memory
Step 8	Provide feedback on spoken and written summary	Participant will summarize the entire article verbally and in writing without the assistance of keywords.	Intention to select specific words during summary, working memory to hold required information in the phonological loop while producing summary, executive function to plan summary.

Summary and conclusions. Attentive Reading with Constrained Summarization-Written (ARCS-W) is a treatment designed to improve the written and spoken discourse of people with mild aphasia. ARCS-W is based on the treatment Attentive Reading and Constrained Summarization (ARCS; Rogalski & Edmonds, 2008). ARCS is a treatment that addresses the macro and microstructure of spoken discourse by targeting the cognitive linguistic underpinnings of discourse production, namely attention and intention via reading and then producing summaries with the following constraints; 1) No non-specific words, 2) Stay on topic.

ARCS-W builds on the platform created by ARCS to target both spoken and written discourse via constrained summarization. There is preliminary evidence that the unique combination of the written/spoken modality and the cognitive skills required for ARCS-W can be efficacious in people with mild aphasia (Obermeyer & Edmonds, 2016). This study fills a gap in clinical treatment research for written text level treatment in people with mild aphasia since many writing treatments target word level expression (see Beeson & Rapcsak, 2002). ARCS-W takes a holistic approach to discourse production that targets the skills required to produce micro and macrolinguistic structure in spoken and written language, which promotes generalization to untrained tasks.

Chapter 2: Study 1

The purpose of this phase I study (Robey, 2004) was to examine the preliminary efficacy of ARCS-W in people with mild aphasia. According to Robey (2004), a phase one study should demonstrate proof of concept and feasibility of a new treatment.

Research Questions

In this study, we administered ARCS-W to persons with mild aphasia to determine if and to what extent ARCS-W:

- 1) Affects micro- (e.g., percent correct information units and complete utterances) and macrolinguistic (percent main concepts) written discourse abilities at post-treatment and one month after treatment (maintenance).
- 2) Affects spoken discourse abilities at both a micro- and macrolinguistic level at post-treatment and maintenance.
- 3) Affects other measures of language, including aphasia severity, confrontation naming (spoken and written), and functional communication.

It was hypothesized that participants who received ARCS-W would demonstrate improvement in written and spoken discourse abilities at both micro and macrolinguistic levels due to the multi-modality nature of treatment and previous reports of ARCS improving spoken discourse in people with aphasia due to stroke (Rogalski, et al., 2013) and primary progressive aphasia (Rogalski & Edmonds, 2008). To capture change in discourse, a variety of discourse types and tasks were implemented with a range of complexity. We also predicted reduced aphasia severity (Western Aphasia Battery-Revised part 1 (WAB-R; Kertesz, 2007)), since ARCS-W is a multi-modality treatment which requires integration of spoken and written information. Improved written and spoken confrontation naming (Object and Action Naming

Battery (OANB; Druks & Masterson, 2000)) was predicted due to the treatment's focus on retrieving lexically specific items in the discourse context. Improved functional communication by proxy report (Communication Effectiveness Index (CETI; Lomas et al., 1989)) was also hypothesized to increase since improvement in discourse could potentially result in functional gains that could be captured by communication partner rating.

Methods

Participants. Three monolingual English speaking participants were recruited from the Edward D. Mysak Clinic for Communication Disorders at Teachers College, Columbia University and surrounding speech clinics in the New York City area. Participants met the following inclusion criteria: 1) diagnosis of mild aphasia and dysgraphia, 2) mild or within normal limits (WNL) performance on the Cognitive Linguistic Quick Test (CLQT; Helm-Estabrooks, 2001), and 3) no history of neurological diagnosis, language/learning disability, or substance abuse. Mild aphasia was diagnosed based on a Western Aphasia Battery-Aphasia Quotient of 76/100 and higher (Kertesz, 2006). Additionally, inclusion required phrase level writing abilities which were screened with the WAB-R, Part 2. See Table 2.1 for standardized test results.

Participant 1 (P1), a 72-year-old male, was 29-months post-ischemic left MCA stroke diagnosed with mild-to-moderate conduction aphasia per the WAB-R (Kertesz, 2006). P1 presented with mild dysgraphia characterized by phonological errors and a disproportionate impairment in his ability to use the nonlexical route/write nonwords. He reported a history of a fluency disorder, for which he received treatment as a child. P1 was a retired accountant who lived independently. He was ambulatory and able to write with his dominant (right) hand.

Participant 2 (P2), a 78-year-old female, was 80-months post-ischemic left middle cerebral artery stroke diagnosed with mild anomic aphasia based on the WAB-R. P2 presented with mild dysgraphia characterized by impairment in both the lexical and nonlexical route. P2 demonstrated semantic errors and reduced accuracy writing nonwords. She worked as a psychoanalyst and adjunct professor prior to her stroke. She lived with her daughter, was ambulatory and able to write with her dominant (right) hand.

Participant 3 (P3), an 84-year-old female 50-months post stroke, was diagnosed with mild anomic aphasia based on the WAB-R. P3 presented with mild dysgraphia characterized primarily by semantic, neologistic and perseverative errors. She was a retired opera singer who lived with her daughter since her stroke. She required a wheelchair for ambulation and wrote with her non-dominant hand (left).

Table 2.1
Standardized Test Results from Pre- to Post-Treatment for All Participants

Measures	Participant 1		Participant 2		Participant 3	
	Pre-tx	Post-tx	Pre-tx	Post-tx	Pre-tx	Post-tx
WAB-R Aphasia Quotient	75.3	82.5*	85.9	88.2	87.3	84.8
WAB-R Language Quotient	82.3	85.0	91.7	93.2	85.5	84.2
WAB-R Cortical Quotient	83.13	87.25	90.78	93.05	86.98	86.43
CLQT-Attention	WNL	WNL	WNL	WNL	WNL	WNL
CLQT-Memory	Mild	WNL	WNL	Mild	Mild	Mild
CLQT-Language	Mild	WNL	WNL	WNL	Mild	Mild
CLQT-Executive Function	WNL	WNL	Mild	Mild	Mild	WNL
CLQT-Visuospatial	WNL	WNL	WNL	WNL	WNL	WNL
CLQT- Composite	WNL	WNL	WNL	WNL	Mild	WNL
CETI Average	n/a	n/a	42.38	66.19**	62.97	70.13

Note. WAB-R (Western Aphasia Battery-Revised); CLQT (Cognitive Linguistic Quick Test); CETI (Communicative Effectiveness Index).

* Indicates improvement of 5 points or more on the WAB

** Indicates statistically significant change ($p < .05$) on Wilcoxon Rank Test.

Design. This study was an experimentally controlled within subject pre-post treatment design.

Assessment. Pre-treatment assessment included four visits. During those visits, The WAB-R Parts 1 and 2 (Kertesz, 2006) were administered to evaluate aphasia severity. The OANB-Age of acquisition lists (Druks & Masterson, 2000) were administered to evaluate confrontation naming of 50 nouns and verbs in spoken (Set A) and written (Set B) modalities. The CETI (Lomas, et al, 1989) was administered to participants' communication partners to measure functional communication. The CETI was standardized using communication partners of people with aphasia and has demonstrated good test-retest and inter-rater reliability. Communication partners rate their partner with aphasia's ability to complete communication tasks (e.g. discussing something in depth, providing yes/no responses) on a visual analog scale with endpoints from "not at all able to" to "as able to as before the stroke". Unlike the protocol reported by Lomas and colleagues (1989), the communication partner rated the person with aphasia's communication pre-treatment and post-treatment without knowledge of their previous ratings, consistent with the protocol reported by Edmonds et al. (2009). The CLQT (Helm-Estabrooks, 2001) was administered to screen for cognitive impairment and determine if participants met inclusion criteria.

Pre-treatment discourse sampling was also completed in writing/typing and speaking and included Nicholas and Brookshire stimuli (N&B; 1993), Story Retelling (DCT; Brookshire & Nicholas, 1997) and four summarization probes. The probes were used to evaluate the participants' ability to summarize novel articles over time. Control probes administered at the same time points as the summarization probes included writing to dictation of nonword stimuli from the John's Hopkins Dyslexia and Dysgraphia Battery (Goodman & Carramazza, 1986) for

P1 and P2 and backward digit span for P3. Detailed procedures for discourse and control task are included below. All measures were re-administered at post-treatment. At maintenance, only confrontation naming and discourse were evaluated.

Therapy protocol. For each treatment session, participants summarized a current event news article in the spoken and written modalities with prescribed constraints. Treatment materials included current event news articles written at the sixth grade reading level obtained from online news sources such as www.news1a.com. Article length varied, since each participant worked at a different speed. Participants were asked about topics they found interesting, and articles related to those topics were selected for treatment. Constraints/rules were 1) Use specific words (i.e., no non-specific words, including pronouns) and 2) Stay on topic (i.e., no opinion, digressions, etc.). The first constraint was intended to improve retrieval of specific lexical items and the second constraint was to improve topic maintenance. Because each participant presented with unique impairments that impacted discourse production, a third constraint was added based on each participant's needs. P1 and P2 would make multiple attempts to spell a word during written summarization. Therefore, their third constraint was "try twice to spell a word and then move on". This constraint was intended to encourage participants to focus on content versus spelling individual words. P3 presented with perseveration in spoken and written discourse; therefore, her third constraint was "look and listen for repeated information". This constraint was intended to increase awareness of perseveration and potentially reduce it. At every session, participants were presented with two-three articles to choose from to promote interest and involvement in each session. The clinician then read the entire article aloud. Next, the participants silently read a segment of the article with the intent to summarize. (Note: P1 listened to the article being read to him due to a relative impairment in

auditory comprehension that he exhibited, see below). For each segment participants identified key words and compared them to a set of keywords the clinician had identified. Next, the participants summarized the segments verbally and then in writing using their key words as a guide. During summarization, participants followed the prescribed constraints. After producing their summaries, participants evaluated their spoken and written production with respect to their constraints and then received clinician feedback. If constraints were violated, the clinician did not interrupt, but gave feedback after the summary was complete. These steps were repeated until the entire article was summarized. Then the participants re-read the complete article silently and summarized it in its entirety verbally and then in writing, without the assistance of key words. Participants were then prompted to rate the completeness of their summary on a scale of 1-5, with 1 being not at all complete and 5 being entirely complete. See Appendix A for detailed description of the protocol for study one. As previously mentioned, P1 listened to treatment material instead of reading. During pre-treatment assessment, he identified auditory comprehension as an area he wanted to address. Since auditory comprehension was a relative weakness for him (as compared to reading comprehension), listening and then summarizing addressed his communication needs while still maintaining the theoretical premise of ARCS-W to attend with the intent of summarization.

Treatment fidelity was completed by a trained research assistant. The research assistant was given a checklist of the treatment steps and watched recorded sessions to determine if the treatment protocol was followed. Our goal was to complete treatment fidelity for at least 30% of sessions. Reliability was completed for 50% of sessions with a reliability of 99.2% for P1, 31.5% of sessions with 100% reliability for P2, and 38% of sessions with 97.75% reliability for P3.

Our a priori intended dosage was four pre-treatment visits, 24 treatment visits, four post-treatment visits and two-three maintenance visits. Assessment (2 hour sessions) and treatment (1 hour 30 minute sessions) were completed at the rate of twice per week. P1 followed this schedule. P2 attended fewer treatment sessions (19) than the other two participants due to medical and transportation complications. Additionally, she required a one month break after the fifth treatment session. In total, P2 attended four baseline assessment visits, 19 treatment sessions, four post-treatment testing session and three maintenance assessment visits (1 month after treatment). P3 attended four baseline assessment visits, 28 treatment sessions, five post-treatment assessment visits and three maintenance assessment visits (1 month after treatment). P3 had more treatment sessions due to travel during the treatment phase. Without extending the treatment phase, she would not have been able to complete post-testing until approximately one month after treatment ended. Therefore, the treatment phase was extended four visits (i.e. two weeks) which were completed when she returned from traveling and were followed immediately by post-treatment.

Materials

Discourse tasks. Post-treatment and maintenance discourse improvement was evaluated with written and spoken samples elicited from story retelling (DCT: Brookshire & Nicholas, 1997) similar to Doyle and colleagues (1998). However, no picture stimuli were used to aid retelling. Participants listened to each story twice and retold half (6) of the stories verbally and half (6) in writing. The stimuli and protocol from N&B (1993) were completed similarly, as half of the discourse prompts were completed verbally (Set B) and half were completed in writing (Set A). Brookshire and Nicholas (1994) found that these two sets had high test-retest stability, and that test-retest stability was higher when multiple stimuli were

administered. The N&B stimuli include picture descriptions (static and sequential), personal narrative and procedural discourse.

Summarization probes. Summarization probes were developed to evaluate whether participants improved in their ability to summarize novel articles in the written modality. The articles used to prompt summarizations were 200-250 words in length. Each probe represented a unique article covering different topics that were not trained or repeated throughout assessment and treatment. Each article was at the sixth grade level based on the Flesch Kincaid scale, which uses sentence length and word length to determine the approximate grade level in which a passage should be understandable (Kincaid, Fishburne, Rogers, & Chissom, 1975). Topics varied, but no popular current events were included and temporal information (e.g., dates) was removed. The participants read (P2 and P3) or listened (P1) to the article twice and were then prompted to produce a written summary of the article in their own words as best they could. The specific instructions were as follows: the clinician instructed the participant to “read the article twice and then you will write a summary of what you have read”. After the participant indicated they were done reading the clinician said “now I want you to write a summary of what you just read the best you can.” The participant was given as much time as they needed to produce their summary.

Control task. A control task was administered at the same time points summarization probes were administered. The control task for P1 and P2 was nonword writing to dictation from the John’s Hopkins Dyslexia and Dysgraphia Battery (Goodman & Carramazza, 1986). This task was selected because it is related to the treatment task (e.g. written output) but was not addressed in treatment (i.e., treatment never directly addresses phoneme to grapheme conversion). P3 was highly accurate in nonword writing; therefore, a spoken backward digit span (N=5) was selected as her control task. This task was selected because the cognitive processing and working memory

demands are related to the treatment itself but are not specifically addressed in treatment tasks. All three participants demonstrated stable performance on this task at pre-treatment over three to four visits.

Discourse Analysis

Discourse elicitation procedures were video and audio recorded for transcription, which was completed by trained research assistants. Utterances were broken into T-units (e.g. a main clause with any subordinate clauses) (Hunt, 1966). Transcription included pauses ≥ 2 seconds and mazes, which were defined as filled pauses (e.g. um, uh, eh) and false starts (e.g. t*, tar*). Reliability was conducted for words, pauses, and utterance breaks with the total number of agreements divided by the total possible. Point-by-point transcription reliability was conducted by the first author on 16% of the transcripts with 93.44% reliability for P1, 16% of transcripts with 93.03% reliability for P2 and 17% of transcripts with 92.69% reliability for P3. This included reliability for approximately 15 randomly selected complete transcripts for each participant. Audio or video recording was used to resolve any transcription disagreements.

All transcripts were coded to capture microlinguistic (percent correct information units (%CIUs) and percent complete utterances (%CUs)) and macrolinguistic level (percentage main concepts (%MCs)) discourse elements. %CIUs is a word-level measure where CIUs are intelligible, accurate and relevant to the stimuli (Nicholas & Brookshire, 1993). %CIUs is calculated by dividing the total number of CIUs by the total number of words (See appendix B for example). %CUs is a sentence-level measure which contains 1) a subject, verb and (object) and 2) information that is accurate and relevant to the stimuli (Edmonds, Nadeau, & Kiran, 2009; Edmonds, et al., 2014). For example, in the context of the WAB-R (Kertesz, 2006)

picnic picture, the sentence “The dog is flying the kite” is coded [+SV][-REL][-CU], because it has complete structure but lacks a relevant subject, while “flying a kite” would be coded as [-SV][+REL][-CU], because it is relevant but does not have SV (O) structure. %CUs is calculated by dividing the number of complete utterances by the total number of utterances (see Appendix B for example).

%MCs are story propositions that accurately and completely contain all essential information (Nicholas & Brookshire, 1995). MCs were created for summarization probes by agreement between three speech language pathologists. There were six to seven concepts identified for each article. MCs for the story retelling (Brookshire & Nicholas, 1997) stimuli were extrapolated from the DCT comprehension questions that addressed the main ideas of the stories (N=4). For information that was implied, the information stated in the story that was used to extrapolate the information was accepted (e.g. implied main idea: Neil got the loan, acceptable stated information: the loan officer began filling out the paperwork and said you really need a loan). For N&B, MCs were scored for the following stimuli: Birthday (N=5), Cat in tree (N=4), Argument (N=7) and Directions (N=8) using the MCs defined by Capilouto, et al. (2005, 2006). MCs were scored as either complete (1.0) or incomplete (0.5). Incomplete MCs constituted concepts that were not completely conveyed or a complete concept that was conveyed over more than one utterance in which each portion of the concept would be scored as 0.5. For example, one MC identified for the story retelling task was “Neil went to the bank to get a loan”. If participants conveyed this information over two utterances (e.g. Neil went to the bank. He needed to take out a loan), then each utterance would be coded as 0.5 for a total score of 1 (i.e., a complete MC). If the information was incomplete (e.g. Neil went to the bank), it would be scored as an incomplete MC (0.5). The percent of main concepts was calculated as

the number of concepts conveyed over the number of concepts possible (see Appendix C for example).

Transcription was completed by trained research assistants. Point-by-point coding reliability was conducted by the primary investigator on 18.8% of transcriptions with high reliability (words=98.98%, CIUs=95.5%, CUs=89.33%, MCs=89.7%) for P1, 20% of transcripts for P2 with high reliability (words=99.39%, CIUs=90.4%, CUs= 92.42% MCs=87.87%) and 20% of transcripts for P3 with high reliability (words=99.6%, CIUs=89.3%, CUs=88.4%, MCs=83.05%). Reliability was completed for a greater percentage of MCs, since there was more potential for variability (30% of MC coding for P1 and P2 and 41% of MC coding for P3). Coding disagreements were resolved through consensus between the original coder and the reliability coder.

Data analysis. The averages for discourse tasks and outcome measures completed across participants over pre-treatment, post-treatment and maintenance are reported. Due to the lack of normative data for these measures in the written modality, a change of ten percentage points or greater was used to signify an improvement.

The results of language testing for research question three are reported. A clinically significant improvement on the WAB-R (Kertesz, 2006) was defined as a change of five points or more on the Aphasia Quotient (Kertesz, 2006). A significant improvement in confrontation naming was defined as an increase of two or more standard deviations on the Object and Action Naming Battery (Druks & Masterson, 2000) (SD objects = 2.72, SD actions = 4.1), and a significant change on the CETI (Lomas, et al., 1989) was determined by comparison of pre- and post-treatment results on a Wilcoxon Signed Rank Test (Wilcoxon, 1945).

Results

P1: Research question 1: Effect of ARCS-W on written discourse.

Written N&B (1993). Change in %CIUs did not meet our criteria for improvement from pre- to post-treatment (80.6-89.0%) and at maintenance (89.3%). %CUs increased from pre- to post-treatment (62.1%-80.2%) and were maintained one month after treatment (88.3%). No changes were observed in %MCs from pre- to post-treatment or one month after treatment (See Table 2.2).

Written story retell. Negligible change was observed in %CIUs. %CUs increased from 69.8% to 80.5% at post-treatment, with maintenance of improvement (81.4%). A substantial increase in %MCs was observed from pre- to post-treatment (58.3%- 87.5%) with maintenance of improvement (77.1%) (See Table 2.2).

Summarization probes. The results reported here are averages from four novel pre-treatment probes, four post-treatment probes and two maintenance probes. Each probe represents a unique article that was not repeated or trained. See Figure 2.1. %CIUs did not change from pre-treatment to post-treatment or at maintenance. %CUs increased from 49% to 77.4% at post-treatment and were maintained at 70.8% one month after treatment. %MCs increased from 40.2% to 60.4% at post treatment and 79.2% at maintenance testing 1-month post-treatment.

Control task. No changes were observed on the nonword writing (Johns Hopkins Dyslexia and Dysgraphia Battery; Goodman & Caramazza, 1986) control task performance from pre- to post-treatment (0.0%) or at maintenance testing (0.0%). See Figure 2.1.

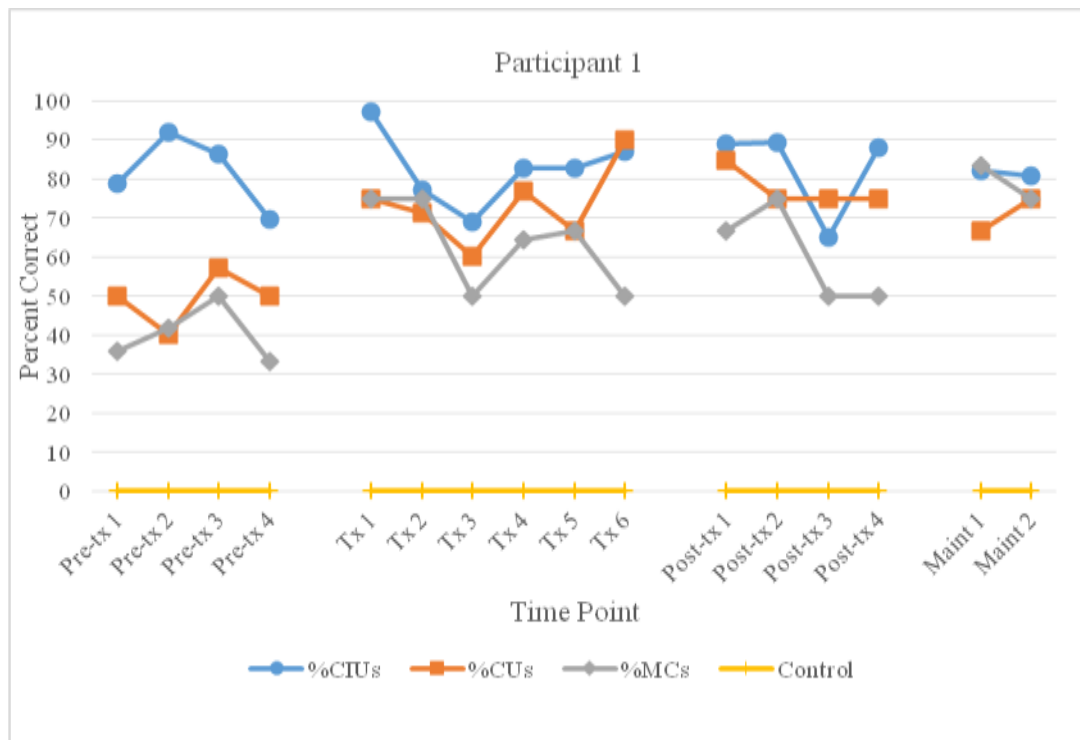


Figure 2.1. P1 percent accuracy for discourse measures in summarization probes and control probes across pre-treatment, treatment, post-treatment and maintenance visits.

Note. Pre-tx=pre-treatment, tx=treatment, post-tx=post-treatment, maint=maintenance; %CIUs=percent correct information units, %CUs= percent complete utterances, %MCs=percent main concepts, Control= percent accuracy in nonword writing (N=10).

P1: Research question 2: Effect of ARCS-W on spoken discourse.

Spoken N&B (1993). An increase from pre-treatment to maintenance was observed for %CIU (56.8%-60.6%-68.5%). %CUs increased from pre- to post-treatment (44.3%-58.4%) with a continued increase at maintenance testing (70.0%). From pre- to post-treatment %MCs went from 46.88% to 40.63% and 56.25% at maintenance.

Spoken story retell. No changes in word relevance were observed. %CUs in spoken story retelling were 58.0% at pre-treatment and 62.0% at post-treatment with an increase at maintenance (74.4%). %MCs increased from pre- to post-treatment (63.0-75.0%) and were maintained (79.2%).

P1: Research question 3: Effect of ARCS-W on measures of aphasia severity, confrontation naming and functional communication.

For P1, a clinically significant increase of >5 points (Katz & Wertz, 1997) on the WAB-R was observed (see Table 2.1). Pre-treatment confrontation naming on an OANB (Druks & Masterson, 2000) was high on nouns and verbs and remained high at post-treatment and maintenance (see Table 2.3). The CETI (Lomas, et al., 1989) was not administered because a communication partner was not available.

Although the current research questions did not address cognition, P1 improved from mild to within normal limits on both memory and language domains.

P2: Research question 1: Effect of ARCS-W on written discourse.

Written N&B (1993). Increases in word and sentence level relevance were observed on the N&B (1993) written discourse tasks from pre- to post-treatment to maintenance. %CIUs went from 67.3% to 75.2% from pre- to post-treatment, with an increase from pre-treatment to maintenance (78.2%) and %CUs improved from 44.1% to 66.3% with a decrease at maintenance to 52.3%. %MCs increased from 34.3% at pre-treatment to 70.7% at post-treatment and were maintained at 76.4%, one month after treatment (See Table 2.2).

Written story retell. No improvement was noted in written story retelling for %CIUs pre- to post-treatment or at maintenance. %CUs did not change from pre- to post-treatment (67.7%-67.8%), but did increase at maintenance (78.1%). No change was observed in %MCs from pre- to post-treatment or at maintenance. See Table 2.2.

Summarization probes. Here averages from four pre-treatment, three post-treatment and two maintenance probes are reported (see Figure 2.2). Each probe represents a unique article that was not repeated or trained. No increases were noted on summarization probes for %CIUs (76.6-72.2%), %CUs (49.9-55.2%) or %MCs (33.0-36.5%). At maintenance, no increase was observed when comparing pre-treatment %CIUs (85.9%); however, there was an increase in %CUs

(69.1%) and %MCs (54.2%).

Control task. P2 demonstrated increased accuracy on the nonword writing control task (Johns Hopkins Dyslexia and Dysgraphia Battery; Goodman & Caramazza, 1986) from 46.0% to 55.9% from pre- to post-treatment and 54.4% at maintenance. See Figure 2.2.

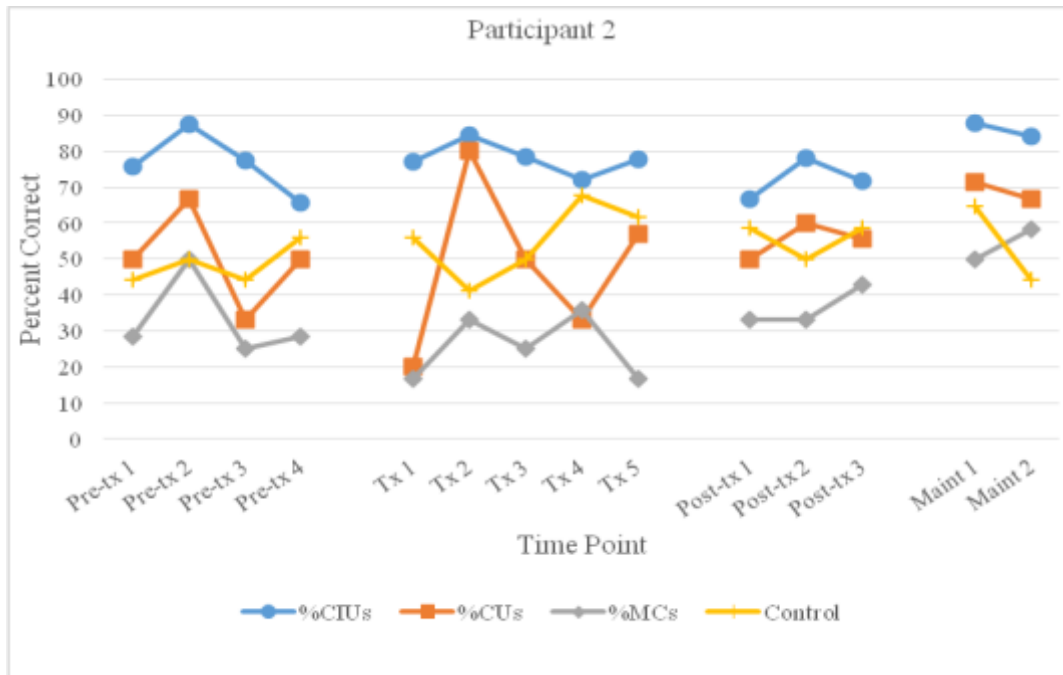


Figure 2.2. P2 percent accuracy for discourse measures in summarization probes and control probes across pre-treatment, treatment, post-treatment and maintenance visits.
 Note. Pre-tx=pre-treatment, tx=treatment, post-tx=post-treatment, maint=maintenance; %CIUs=percent correct information units, %CUs= percent complete utterances, %MCs=percent main concepts, Control= percent accuracy in nonword writing (N=34).

P2: Research question 2: Effect of ARCS-W on spoken discourse.

Spoken N&B (1993). Word level relevance (%CIUs) was at 50.5% pre-treatment and 59.9% at post treatment with an increase from pre-treatment to maintenance (67.5%). %CUs did not improve (47.8%-42.8%) from pre- to post-treatment, but did at maintenance testing (63.8%). A similar pattern was observed with %MCs (pre-treatment and post-treatment = 34.4%, maintenance = 53.1%).

Spoken story retell. Negligible changes were observed across micro or macrolinguistic measures. See Table 2.2.

P2: Research question 3: Effect of ARCS-W on aphasia severity, confrontation naming and functional communication.

For P2, no clinically significant improvement was observed on the WAB-R (see Table 2.1). P2 demonstrated an increase on confrontation naming on the OANB Age of Acquisition List on written nouns (82%-94%) and spoken actions (60%-84%). These increases were maintained for written nouns (92%) with some decrease in spoken actions (70%). No substantial change was observed in spoken nouns or written actions. See Table 2.3 for results. A statistically significant improvement was measured on the CETI (Lomas, et al., 1989) based on the Wilcoxon Rank Test with $P < .05$. See Table 2.1 for results.

P3: Research question 1: Effect of ARCS-W on written discourse.

Written N&B (1993). Increases in word and sentence level relevance was observed from pre- to post treatment with %CIUs increasing from 48.04% to 76.17%. Further increase was noted at maintenance (88.96%). %CUs increased from 43.75% to 75.19% from pre- to post-treatment with a further increase to 89.33% at maintenance. The %MCs conveyed increased from 44.29% at pre-treatment to 78.57% at post-treatment with a decrease observed at maintenance to 51.43%. See Table 2.2.

Written story retell. P3 completed four written retellings, opposed to six, due to fatigue during testing. P3 improved on microlinguistic measures. %CIUs increased from pre- to post-treatment (66.4%-76.7%) and went to 74.5% at maintenance. A larger increase was observed in sentence level relevance (%CUs: 54.3- 71.0%) and was maintained (66.9%). No change in %MCs was observed (See Table 2.2.)

Summarization probes. Here the averages from four pre-treatment, two post-treatment and two maintenance probes are reported. Each probe represents a unique article

that was not repeated or trained. No post-treatment or maintenance improvements were made on %CIUs, %CUs, or %MCs.

Control task. On the backward digit span control task an increase of 10.0%-35.0% was observed from pre- to post treatment, which decreased to 25.0% at maintenance testing. See Figure 2.3.

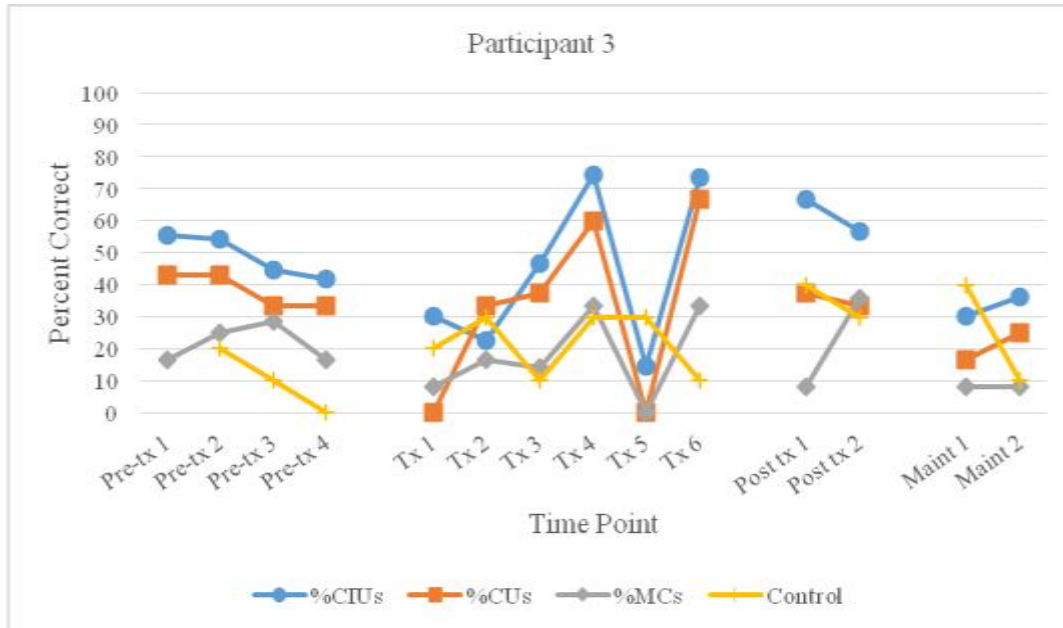


Figure 2.3. P3 percent accuracy for discourse measures in summarization probes and control probes across pre-treatment, treatment, post-treatment and maintenance visits.
 Note. Pre-tx=pre-treatment, tx=treatment, post-tx=post-treatment, maint=maintenance; %CIUs=percent correct information units, %CUs= percent complete utterances, %MCs=percent main concepts, Control= percent accuracy in backward digit span (N=10).

P3: Research question 2: Effect of ARCS-W on spoken discourse.

Spoken N&B (1993). No change was measured in %CIUs from pre- to post treatment or at maintenance testing. %CUs did not change from pre- to post-treatment (37.2%-41.4%) but did increase at maintenance testing (54.3%). No change was observed in the %MCs conveyed from pre- to post-treatment (37.5%); However, there was an increase one-month post-treatment (50.0%) Note: The cat and tree stimulus item was inadvertently omitted at post-treatment; however, it was included in pre-treatment and maintenance analysis.

Spoken story retell. P3 completed four spoken retellings, opposed to six, due to fatigue during testing. %CIUs was at 47.4% at pre-treatment and 54.2% at post-treatment with an increase from pre-treatment to maintenance (58.6%). %CUs followed a similar pattern with no increase from pre-to post-treatment (46.1%-54.9%), but improvement from pre-treatment to maintenance (46.1%-64.1%). %MCs were at 53.1% pre-treatment and 62.5% at post-testing with an increase to 68.8% observed at maintenance compared to pre-treatment (53.1%).

^a Table 2.2
Written and Spoken Discourse Results for All Participants at Pre-Treatment, Post-Treatment and Maintenance for All Outcome Measures

	Participant 1		Participant 2		Participant 3					
	Pre-tx	Post-tx	Pre-tx	Post-tx	Pre-tx	Post-tx				
Written N&B (1993) Outcomes										
%CIUs	80.59	89.01	89.33	89.33	67.26	75.24	78.21	48.04	76.17	83.86
%CUs	62.05	80.18	88.30	88.30	44.11	66.92	52.03	43.75	75.19	89.33
%MCs	62.14	56.43	55.71	55.71	34.28	70.71	76.43	44.29	78.57	51.43
Written Story Retelling Outcomes										
%CIUs	82.61	89.35	84.90	84.90	85.11	84.88	88.56	66.40	76.68	74.51
%CUs	69.83	80.46	81.44	81.44	67.66	67.85	78.08	54.31	71.00	66.88
%MCs	58.33	87.50	77.08	77.08	75.00	72.92	70.83	46.88	50.00	46.88
Spoken N&B (1993) Outcomes										
%CIUs	56.80	60.57	68.54	68.54	50.50	59.87	67.46	43.30	42.47	51.54
%CUs	44.33	58.41	70.01	70.01	47.78	42.84	63.79	37.18	41.43	54.29
%MCs	46.88	40.63	56.25	56.25	34.38	34.38	53.13	37.50	37.50	50.00
Spoken Story Retelling Outcomes										
%CIUs	65.60	67.48	70.92	70.92	60.42	63.63	64.39	47.39	54.17	58.59
%CUs	57.94	61.92	74.37	74.37	60.09	65.27	56.22	46.06	54.88	64.11
%MCs	62.50	75.00	79.17	79.17	72.92	74.58	68.75	53.13	62.50	68.75

Note. Pre-tx= pre-treatment, post-tx= post-treatment. %CIUs= percent complete information units; %CUs= percent complete utterances; %MCs= percent main concepts.
 A change from pre-treatment of 10 percentage points or more is in boldface.

P3: Research question 3: Effect of ARCS-W on aphasia severity, confrontation naming and functional communication.

For P3, no clinically significant improvement was seen on the WAB-R Aphasia Quotient. See Table 2.1 for results. Confrontation naming accuracy did not increase (See Table 2.3). Raw scores on the CETI did increase beyond the SEM of 5.2 reported in Lomas et al. (1989); however, not substantially enough to render a statistically significant result. Although the current research questions did not address cognition, P3 demonstrated an improvement from mild to within normal limits in the executive function domain.

Table 2.3.

Confrontation Naming Results of Objects and Actions in Speaking and Writing at Pre-, Post-Testing and Maintenance Periods for All Participants

Measure	Participant 1			Participant 2			Participant 3		
	Pre-tx	Post-tx	Main	Pre-tx	Post-tx	Maint	Pre-tx	Post-tx	Maint
OANB, N=50	100%	100%	100%	92%	94%	84%	84%	92%	94%
Objects Spoken	100%	100%	100%	92%	94%	84%	84%	92%	94%
Objects Written	92%	94%	82%	82%	94%	92%	86%	92%	92%
Actions Spoken	88%	88%	84%	60%	84%	70%	94%	94%	96%
Actions Written	88%	84%	84%	70%	80%	68%	92%	88%	96%

Note. OANB=Object and Action Naming Battery-Age of Acquisition List; changes of 2 standard deviations or greater are boldface.

Discussion

The purpose of this study was to determine the preliminary efficacy of ARCS-W in people with mild aphasia. All participants improved in written and spoken discourse, providing evidence of the ability for ARCS-W to improve written discourse, while replicating the positive treatment effects in spoken discourse previously observed with ARCS (Rogalski & Edmonds, 2008; Rogalski, et al., 2013). ARCS-W was administered to people with mild aphasia. Limiting the population to those with mild aphasia was important due to the complex written language and self-monitoring required for successful completion of the treatment tasks. In addition, ARCS-W

is a top-down holistic approach to language rehabilitation which addresses participants' abilities to integrate the cognitive-linguistic skills required for written and spoken discourse production. As a result, ARCS-W requires that participants have relative strengths in regard to word retrieval and production of a sentence frame (written and spoken) in isolation, since the treatment does not target specific linguistic mechanisms.

While each participant demonstrated a unique response to treatment, some patterns were observed across participants. All participants had lower pre-treatment results on discourse outcomes in the spoken modality than the written modality. This finding is likely due to the nature of spoken discourse and how it is evaluated. During spoken discourse tasks, participants produced more revisions and their word retrieval difficulties were penalized (e.g. circumlocution, revision, multiple attempts to produce a word). In writing they took more time to think about retrieving a word and strategies such as circumlocution were infrequent. Additionally, participants were not penalized for crossing words out. This finding illuminates the need for further research into modality differences between spoken and written discourse in people with aphasia, especially those with mild aphasia.

Regardless of participant or modality, the largest treatment effects were observed at the sentence level. All three participants demonstrated basic sentence construction abilities pre-treatment; therefore, sentence level change was primarily a result of their ability to convey relevant and informative content within the sentence. One possible explanation for this finding is that participants had relatively high pre-treatment %Correct Information Units, especially in writing, but would often use nonspecific words when constructing sentences. Treatment focused on the selection of semantically specific words, which improved sentence level relevance in generalization tasks. The specific mechanisms are described below.

Discourse is both cognitively and linguistically taxing with varied demands required depending on discourse type (e.g. procedural, descriptive, narrative). For this study, the discourse outcomes included a variety of types (procedural, picture description, personal, narrative, and expository) and tasks (N&B, story retelling, article summarization). Of the discourse tasks administered, the most improvement across participants was observed on the N&B stimuli (1993). This improvement cannot be attributed to type of discourse, since N&B encompasses procedural, picture description, and personal narratives. Participants demonstrated lower pre-treatment results on the N&B prompts in speaking and writing when compared to the story retelling task, but also demonstrated the most improvement after treatment on the N&B prompts. It is possible that the linguistic demands of the N&B stimuli made the task more difficult prior to treatment, but also allowed for the most improvement. Participants demonstrated less consistent gains on the story retelling task, but typically demonstrated better performance on this task pre-treatment. Although the story retelling task is more cognitively taxing (recalling information), it is possible that being exposed to the lexical items when hearing the story bolstered the participants' performance by improving their ability to retrieve those items during their retellings.

Another pattern observed across participants was increased performance from post-treatment to maintenance. This pattern has been reported previously (see Edmonds et al., 2014) and could potentially be related to fatigue after a long period of pre-testing and treatment. Importantly, none of the participants in this study received individual or group-based speech language services through the duration of pre-testing, treatment, post-testing or maintenance testing; therefore, the improvements observed at maintenance were likely delayed treatment effects. This finding stresses the importance of maintenance testing in research and

potentially in clinical settings.

Mechanisms of improvement. All participants improved in some aspect of spoken and written discourse, but the mechanisms for improvement varied. P1 exhibited the most robust and widespread improvements across outcome measures and tasks. One possible explanation may be related to the modality of presentation of the treatment stimuli. P1 listened to the articles he had to summarize during treatment instead of reading. As a result, he had to remember and independently recall information when he had to identify and write down his key words, which resulted in greater demands on memory and lexical access. The other participants read the treatment material and could use the written article to identify and write keywords, looking back if needed, which did not require as much independent recall. Another factor could be that P1 demonstrated the strongest written discourse abilities (e.g. highest percent correct information units and percent complete utterances) at pre-treatment in combination with excellent single word lexical retrieval. However, his discourse often included nonspecific words, uncorrected word retrieval errors and pronoun confusion. The high-level treatment tasks with accompanying meta-linguistic focus during treatment provided him the opportunity to use specific words and produce appropriate pronouns while receiving feedback from the clinician and monitoring his own output. As a result, his ability to monitor his output and be more specific and complete in discourse may have facilitated the generalization across a variety of discourse tasks that was observed. In addition, P1 did not present with some of the complicating factors observed in P2 and P3. P1 also improved on the Western Aphasia Battery-Revised aphasia quotient as a result of increased scores in spontaneous speech and repetition. Of the three participants, P1 had the most impaired aphasia quotient and therefore, had more room to improve than the remaining participants.

P2's participation was complicated by medical and transportation issues that required a one month break during treatment and for the treatment course to be shortened by 5 sessions. Despite these complications, she made substantial improvements in written and spoken discourse. P2 had the lowest lexical retrieval of single words at pre-treatment and impaired lexical retrieval also impacted her discourse. This was observed most markedly on the N&B (1993) task in which she demonstrated much lower percent correct information units, percent complete utterances and percent main concepts as compared to the story retelling task, which provided linguistic targets. Post-treatment she was the only participant to improve in confrontation naming. The improvement corresponded to increased lexical retrieval in discourse via increased percent correct information units and percent complete utterances on the N&B tasks. Her communication partner also rated her functional communication as higher on the CETI (Lomas, et al., 1989) as a result of perceived improvement in discourse tasks such as participating in a group conversation or having coffee-time visits and conversation with friends or neighbors. Pre-treatment, P2 had a high WAB-R AQ (85.9) and did not make substantial gains after treatment (88.2). In conclusion, P2's primary deficit was lexical retrieval across the linguistic hierarchy (single words and discourse), and increased lexical access appeared to be the mechanism that supported her observed improvements.

P3 presented with mild aphasia and good lexical retrieval abilities on single words during pre-treatment. Yet of the three participants her discourse was the most impaired as evidenced by the lowest percent correct information units and percent complete utterances in discourse tasks. While her CLQT composite score was mild, performance on the subtests in addition to the Ravens Progressive Matrices in the Western Aphasia Battery Part 2 indicated

slower processing for cognitive tasks. Additionally, she exhibited a high degree of perseveration during discourse tasks and variability across sessions that appeared to correspond to fatigue. At post-treatment P3 conveyed more relevant content at the word, sentence and discourse levels. Although in-depth cognitive testing was not completed, it was evident at post treatment that she was responding faster to stimuli, including those within the CLQT. These observations support speculation that P3 increased her processing ability over the course of treatment, which improved her ability to process stimuli and produce more relevant discourse. P3 demonstrated good lexical retrieval in confrontation naming and had a high WAB-R AQ at pre-treatment. She did not make gains in these areas after treatment; however, gains in these areas would not necessarily be expected for someone with her profile in which linguistic skills in isolation (e.g. confrontation naming) are highly accurate, but breakdown during discourse.

The summarization probe task completed in this study was designed to determine if participants improved their ability to summarize novel expository articles. However, this measure proved to be problematic for a variety of reasons. First, each probe was a unique article with variable lexical density and diversity which could impact performance. Additionally, summarization during treatment consisted of scaffolding and feedback with short segments of the text which did not occur during probes. Therefore, the probe task was more cognitively and linguistically challenging than the treatment itself. P1's improvement on the probe task could be related to the methodological difference of listening during treatment which required more independent recall (i.e., not assisted by reference to the written text). Additionally, P1 had the best discourse ability pre-treatment and therefore, was able to summarize longer articles (200-250 words) in treatment and summarize the probe articles more

successfully. Alternatively, P3 was only able to summarize 100 word articles during treatment which made summarizing the 200-250-word probe articles much more cognitively taxing. Thus, the probe task was not appropriate to capture improvements in the trained task due to a large gap in complexity between treatment and the probe task itself.

Selecting a control task for this treatment study proved difficult, since the treatment addresses written and spoken discourse with additional intent to engage intention/attention, memory and executive function skills, which could result in improvement in a variety of cognitive and linguistic tasks. P1 did not improve on the control task of nonword writing; however, P2 and P3 improved slightly on their control tasks. P2 completed nonword writing as a control task and started off with relatively high accuracy (46%) which improved over the course of treatment. Although no explicit phoneme to grapheme correspondence tasks were completed during treatment, the multimodality treatment required reading, writing and speaking the same linguistic targets, which provided opportunities for P2 to make and practice phoneme to grapheme connections and improve her relatively strong skills independently. P3 exhibited extremely high accuracy on nonword writing; therefore, a backward digit span task (five digits) was selected as her control task. P3 improved on this task, which is consistent with the hypothesis that increases in her processing and other cognitive skills may have supported her linguistic improvements.

Clinical implications and future directions. The current study represents phase I (Robey, 2004) in providing preliminary efficacy for ARCS-W. According to Robey, the purpose of a phase I study is to determine feasibility of a treatment and if positive and interpretable results are achieved. In this study, three participants with mild aphasia demonstrated positive results in both written and spoken untrained discourse outcomes.

ARCS-W is a treatment for written discourse in people with mild aphasia, potentially filling a gap in clinical treatment research. ARCS-W treatment also addresses spoken discourse via its multi-modality approach. The treatment implements constraint at levels that address micro and macrolinguistic discourse structure to increase intentional language use (Nadeau, Rothi & Rosenbek, 2008; Rogalski & Edmonds, 2008). The constraints also require participants to self-monitor and evaluate their discourse production. This top down approach emphasizes the communicative intent of discourse and facilitates generalization to untrained discourse topics and types.

Chapter 3: Dissertation Study (Study 2)

This is a phase II study (Robey, 2004) which sought to refine the ARCS-W protocol and attempt to replicate the results observed in study one with a second cohort of people with mild aphasia. Thus, study two, the dissertation study, was informed by the results of study one. Changes include two adjustments to the treatment protocol and more extensive outcome measures to capture discourse ability at both a micro and macrolinguistic level as well as global language skills. Many of the methods reported for study two are the same or similar to those reported in study one. Changes to the protocol are noted and corresponding rationales are provided.

Purpose Statement

The purpose of this research study was to evaluate the effect of ARCS-W in two people with mild aphasia within an experimentally controlled single subject pre- to post-treatment design. This was accomplished by answering the following questions.

- 1) To what extent does ARCS-W affect micro and macro linguistic written discourse abilities at post-treatment and one month after treatment (maintenance)?
- 2) To what extent does ARCS-W affect spoken discourse abilities at both a micro and macrolinguistic level at post-treatment and maintenance?
- 3) To what extent does ARCS-W affect other measures of language, including confrontation naming (spoken and written), sentence production and functional communication?
- 4) To what extent does ARCS-W affect cognitive-linguistic abilities?

Hypotheses

Research question 1. To what extent does ARCS-W affect micro and macrolinguistic

written discourse abilities at post-treatment and one month after treatment in two people with mild aphasia? ARCS-W is a new treatment created to improve spoken and written discourse in people with mild aphasia. It was adapted from ARCS (Rogalski & Edmonds, 2008; Rogalski, et al., 2013), which was designed to address spoken discourse and word finding. ARCS-W is innovative in its combined treatment of written and spoken discourse. The addition of written summarization in ARCS-W provides greater opportunity for self-monitoring skills and error detection/correction as well as the ability to improve written discourse in people with aphasia. Not only is discourse addressed in the ARCS-W treatment, but it is done with components of the Hayes (1996) text writing model in mind. This model provides a theoretical groundwork for targeting discourse level writing in people with mild aphasia. It was hypothesized that participants who receive ARCS-W would demonstrate improvement in their written discourse abilities at both a microlinguistic and macrolinguistic level. This research question was evaluated with the following measures: percent of correct information units, percent complete utterances, grammatical complexity, percent of correct main concepts and global coherence. Sentence complexity and global coherence were not evaluated in study one. They were included to obtain a more complete picture of pre-treatment impairment levels and to capture change after treatment. Sentence complexity is a microlinguistic measure designed to determine the grammatical complexity of sentences. In study one, participants made large improvements at the sentence level as indicated by increases in the percent of complete utterances. It is possible that increased lexical retrieval in people with mild aphasia could result in the production of more complex sentences, which would be captured by the sentence complexity measure. Global coherence is a macrolinguistic measure that evaluates topic maintenance and discourse structure. Staying on topic is one of the constraints in ARCS-W and this measure will provide insight into

participants' ability to maintain a topic.

Evidence for this hypothesis was reported in study one, in which all three participants demonstrated improvement across a variety of discourse types on micro- and macrolinguistic measures. Specifically, participant 1 improved on percent complete utterances and percent main concepts conveyed across article summarization, story retelling, and other discourse types. Participant 2 improved percent complete utterances in discourse from Nicholas and Brookshire (1993) elicitation procedure and Participant 3 increased percent correct information units, percent complete utterances and percent main concepts on a variety of written discourse measures. See chapter 2 for complete results.

Research question 2. To what extent does ARCS-W affect micro and macrolinguistic spoken discourse abilities at post-treatment and one month after treatment in two people with mild aphasia? There is evidence that supports using ARCS to improve spoken discourse and word finding ability in people with primary progressive aphasia and Wernicke's aphasia (Rogalski & Edmonds, 2008; Rogalski, et al., 2013). This research question evaluated if the spoken discourse performance of two people with mild aphasia improved after receiving ARCS-W, which focuses primarily on written summarization but also includes spoken summarization. It was hypothesized that participants who received ARCS-W could demonstrate improvement in their spoken discourse abilities due to the multi-modality component of the ARCS-W treatment. Spoken discourse was measured at the microlinguistic level via increased percent correct information units, percent complete utterances and percent of grammatically complex sentences and at the macrolinguistic level via increased percent of main concepts conveyed and global coherence. These measures are the same as those reported in study one except for grammatical complexity and global coherence, which were added to obtain a more complete picture of pre-

treatment discourse performance and the patterns of improvement demonstrated across participants.

It was hypothesized that the meta-linguistic and multi-modality components of ARCS-W would lead to improvement in spoken discourse. Preliminary evidence for this hypothesis was reported in Chapter 2 based on participant 1, 2 and 3 who demonstrated improvement in relation to microlinguistic and macrolinguistic measures in spoken discourse.

Research question 3. To what extent does ARCS-W affect measures of language including confrontation naming, sentence production and functional communication? ARCS-W works at both a microlinguistic and macrolinguistic level while addressing spoken and written discourse. To do this requires multiple modalities including reading and spoken/written summarization. This multi-modality approach has the potential to improve language ability across the linguistic hierarchy in people with mild aphasia. Results from study one reported in Chapter 2 provide preliminary evidence that confrontation naming can improve (e.g., P2) after ARCS-W, but this finding was not consistent across participants. Additionally, there is evidence that ARCS improved confrontation naming in a person with Wernicke's aphasia (Rogalski, et al., 2013). Sentence production ability was not evaluated in study one (Chapter 2) but was included in study two to determine if written or spoken sentence production would improve after ARCS-W treatment. The addition of sentence production as an outcome measure was important to obtain a more complete picture of each participants' pre-treatment profile and their patterns of improvement. There is evidence that sentence production improves after ARCS-W treatment based on the increase in percent complete utterances in participant 1, 2 and 3, which was reported in Chapter 2. Therefore, it is possible that improved accuracy could also be observed in isolated sentence production tasks. In regard to functional communication, ARCS-W is a

discourse level treatment. Since everyday communication often takes place at a discourse level, it is possible that functional communication of people with aphasia will improve after receiving ARCS-W. Participant 2 improved on functional communication in study one based on communication partner report. In study two, self-reported functional communication was also evaluated. It was hypothesized that participants who received ARCS-W could improve their confrontation naming, sentence production and functional communication.

Research question 4. To what extent does ARCS-W affect measures of cognitive linguistic function? Since discourse requires the interaction of cognitive and linguistic skills, working at this level could improve overall cognitive functions. Evidence for this was reported in study one (Chapter 2) in which 2/3 participants improved from mild to within normal limits on specific domains of the CLQT (Helm-Estabrooks, 2001). It is hypothesized that participants who receive ARCS-W will demonstrate improvement in their cognitive linguistic skills. While the CLQT (Helm-Estabrooks, 2001) is not a comprehensive cognitive battery, it can provide preliminary evidence about potential cognitive changes observed after treatment. Additionally, improvements in macrolinguistic measures such as percent of main concepts conveyed and global coherence can provide evidence of improvement in non-linguistic cognitive function. Story propositions, which are similar to main concepts, have been correlated with working memory (Youse & Coelho, 2005; Wright et al., 2011), episodic memory, attention and processing (Wright et al., 2011). The ability to maintain global coherence (i.e., topic maintenance) has been correlated to attention and processing time (Rogalski et al., 2010; Wright et al., 2014). Therefore, improvements in conveying main concepts and maintaining global coherence will also be taken into consideration when interpreting the results of research question four.

Significance

There are approximately one million people living with aphasia in the US. One of the largest obstacles they face is returning to independence. For some, this includes returning to work (National Aphasia Organization, 2011). Both goals require high-level competence in spoken and written language; however, there is a shortage of evidenced-based treatments that target high level spoken and written discourse in people with mild aphasia. The majority of treatments used with people with aphasia, especially those that address writing, focus on the word level (see Beeson & Rapcsak, 2002). While these treatments are essential they often do not meet the needs of people with mild aphasia who seek to improve their written language at the discourse level. Without such options, clinical speech language pathologists are left to treat written discourse impairments without theoretically driven evidenced based treatments.

The proposed project is significant because it will provide further evidence toward support of preliminary efficacy for a treatment, ARCS-W, that addresses the spoken and written discourse production of people with mild aphasia as well as the cognitive skills that are required to produce discourse. The phase I study (Robey, 2004) reported in chapter two presented promising and compelling results. The dissertation study reported in chapters four, five and six represents the second phase toward providing preliminary efficacy for ARCS-W.

Chapter 4: Methods

Research Design

An experimentally controlled within subjects pre- to post-treatment design was used to evaluate the effects of the treatment, Attentive Reading with Constrained Summarization-Written (ARCS-W). This design included four treatment phases or steps: pre-treatment testing, treatment, post-treatment testing and maintenance testing. Outcome measures included scores on standardized test batteries and micro and macrolinguistic measures obtained via written and spoken discourse sampling on untrained tasks.

Recruitment and Consent

All informed consent documentation and study procedures were carried out as approved by the Teachers College Institutional Review Board. Participants were recruited from local rehab facilities and speech-language service centers including those within Teachers College. All participants were consented by the primary investigator who explained study requirements and procedures and answered questions. Participants were given a copy of the consent form to review. If they consented, the participants were asked a series of questions about personal and medical history. In addition, participants were asked to sign a medical release form so that their medical records could be requested from outside facilities. Medical history was required to obtain the most accurate information regarding the location and severity of their stroke lesion and other pertinent treatment information.

Ethical Considerations

People with aphasia often present with impaired expressive and receptive language. To compensate for the possibility of these deficits, the consent form was written at a sixth-eighth grade reading level. The primary investigator, a trained speech language pathologist, described

the study using multiple modalities (e.g. writing, speaking) to encourage comprehension. The person with aphasia could ask questions at any point in the study. In addition, participants could withdraw from the study at any time.

Participants

Participants included two people with mild aphasia and mild-moderate dysgraphia as a result of acquired brain injury who were at least nine-months post onset. The Western Aphasia Battery-Revised Parts 1 and 2 (WAB-R; Kertesz, 2006) was administered to determine type and severity of aphasia. Participants were right-handed, English monolinguals who demonstrated the ability to write at the phrase level (i.e., a sequence of two or more words arranged in a grammatical structure) in at least 50% of written discourse. Mild aphasia was diagnosed based on a Western Aphasia Battery Aphasia Quotient of 76/100 and higher (Kertesz, 2006). Phrase level abilities were determined by the writing portion of the WAB-R Part 2. Exclusionary criteria included history of learning disability, neurogenic disorder/disease other than stroke, alcohol or drug abuse, and depression or other mental health issues. Additionally, participants were excluded if they were more than mildly impaired on the composite score on the Cognitive Linguistic Quick Test (CLQT; Helm-Estabrooks, 2001). See Table 4.1 for pre-treatment standardized test scores.

Participant 100 (P100) was a 66-year-old African American male 45-months post left middle cerebral artery infarct at the time of his participation. He was diagnosed with mild anomia based on the WAB-R (Aphasia Quotient=79.3) and scored within normal limits on the CLQT. He presented with dysgraphia characterized by errors in the lexical (e.g., semantic, lexical) and nonlexical routes (e.g., reduced accuracy writing nonwords to dictation). His reading comprehension was highly accurate based on a 91% composite score on the Reading

Comprehension Battery for Aphasia-2 (RCBA; LaPointe & Horner, 1998). He could write at the phrase level with his non-dominant hand and had a right-hand hemiparesis. P100 was a retired human resources manager for a pharmaceuticals company. Prior to his stroke, he had been active in his church but reported that he no longer attended. He lived with his wife and ambulated independently. P100 was given the choice to receive assessment and treatment in the typed or handwriting modality, and he chose handwriting.

Participant 600 (P600) was a 49-year-old Asian Pacific American male who was 48-months post left posterior parieto-temporal infarct at the time of his participation. He was diagnosed with mild anomic aphasia based on the WAB-R (Aphasia Quotient=86.7) and scored mildly impaired on the CLQT. He presented with dysgraphia characterized by impairment in the lexical (e.g., semantic errors and neologisms) and the nonlexical route (e.g., reduced accuracy writing nonwords). He scored a 91% on the composite score of the RCBA-2 (LaPointe & Horner, 1998), indicating highly accurate reading comprehension. He ambulated independently and had use of both hands. P600 selected typing as his assessment and treatment modality. P600 worked as a stock broker prior to his stroke and had not been able to return to work. He lived with family.

Table 4.1.
Pre-Treatment Language Assessment Results for Both Participants

Measure	Participant	
	P100	P600
Western Aphasia Battery-Revised		
Aphasia Quotient	79.3	86.7
Language Quotient	78.3	81.5
Cortical Quotient	81.9	83.46
Reading Comprehension Battery for Aphasia	P100	P600
Word-Visual	100%	100%
Word-Auditory	100%	100%
Word-Semantic	100%	100%
Functional Reading	70%	90%
Synonyms	90%	90%
Sentence-picture	100%	100%
Paragraph picture	80%	50%
Paragraph factual	100%	90%
Paragraph inferential	90%	100%
Morpho-syntax	80%	90%
Overall Score	91%	91%

Procedures

Participants read and signed the consent form with the principal investigator, who answered questions related to the study. All participants then completed a personal and medical history questionnaire. Next, pre-treatment testing was initiated, and continued at a pace appropriate for the individual participant, over approximately five more visits. The intended time commitment for each participant was 4-6 months consisting of six pre-treatment testing visits, 24 treatment visits (twice-three times a week for 1 hour 30 minutes each time, over 12 weeks), four post-treatment testing visits and four maintenance testing visits one month after treatment.

P100 received the intended dosage which included six pre-treatment visits, 24 treatment visits, five post-treatment visits and four maintenance visits. P600 participated in fewer treatment sessions due to holiday traveling that required treatment to be shortened to accommodate post-treatment testing. In total, P600 attended six pre-treatment assessment visits, 21 treatment visits, and five post-treatment assessment visits. P600 did not complete maintenance testing due to

extended traveling and reported testing fatigue.

Standardized Tests

Administered at pre-treatment only. The WAB-R parts 1 and 2 (Kertesz, 2006) was administered before treatment to determine type and severity of aphasia and preliminary information on the type and severity of dysgraphia. The two participants in this study had mild aphasia and high Aphasia Quotient scores on the WAB-R; therefore, this measure was unlikely to be sensitive enough to capture change after treatment and was not re-administered. The RCBA (LaPointe & Horner, 1998) was administered to determine if participants had adequate reading comprehension skills to complete the therapy tasks.

Standardized outcome measures. The Object and Action Naming Battery (OANB; Druks & Masterson, 2000) was given to assess confrontation naming ability of 162 nouns and 100 verbs. Each participant named half of the stimuli in writing and half spoken (Lists A and B) following the protocol implemented by Furnas and Edmonds (2014).

The Sentence Production Test (SPT; Wilshire, Lukkien & Burmester, 2014) was administered to measure sentence production in speaking and writing with each sentence being produced first in speaking and then in writing. The SPT (Wilshire, et al., 2014) requires that the Person with aphasia describe a pictured event in one sentence. The SPT includes 20 items which represent a range of sentence complexities (i.e. one, two and three place sentences), and lexical items (e.g. fairy, lightning, dog). Wilshire and colleagues reported high response agreement on the stimuli for healthy controls and good interrater reliability. Two scores for the SPT were calculated, the overall sentence accuracy score evaluated every component of the sentence including open class words, closed class words, and word order. An open classed score was also calculated which evaluated the percentage of target nouns and verbs the participant produced

without penalty for morphological or syntactic errors. This score was included to evaluate sentence level lexical retrieval in isolation, since closed class words and syntax were not a target in treatment.

The CLQT (Helm-Estabrooks, 2001) was administered to evaluate cognitive functions such as attention, executive function and memory to determine eligibility for treatment and to measure possible improvement in cognitive-linguistic skills at post-treatment testing and maintenance periods.

Functional communication was evaluated via communication partner report using the Communicative Effectiveness Index (CETI; Lomas, et al., 1989) and self-report using the Aphasia Communication Outcome Measure (ACOM; Hula, et al., 2015). The CETI requires the communication partner to rate the person with aphasia's functional communication in a variety of scenarios such as "having one-on-one conversation" and "communicating aches and pains". The communication partner rates the person with aphasia's ability on a visual analog scale from "not at all able" to "as able as before the stroke" along a 100-millimeter line. The closer to 100 the communication partner marks, the closer to "as able as before the stroke" the person with aphasia is. The CETI was standardized with communication partners of people with aphasia and reported good test-retest and inter-rater reliability (Lomas, et al., 1989). Unlike the protocol reported by Lomas and colleagues (1989), the communication partner rated the person with aphasia's communication pre-treatment and post-treatment without knowledge of their previous ratings. The ACOM (Hula, et al., 2015) was normed on 329 people with aphasia and asks them to rate their own functional communication ability on a visual scale for 56 functional scenarios from the categories of verbal expression, comprehension and writing (Doyle & Hula, 2012) The Person with aphasia rates their communication in scenarios such as "reading nutrition

information on food labels” and “discussing future-plans with friends or family”. Based on their responses a t-score is generated that allows their pre-treatment and post-treatment responses to be compared and compares his/her score to the mean of 329 people with aphasia.

Control Task

A control task was administered to establish experimental control. The control probe was administered at the same time points as the summarization probes, which are described below. The control task was nonword writing to dictation (N=34) using stimuli from the Johns Hopkins Dyslexia and Dysgraphia Battery (Goodman & Carramazza, 1986). This task was selected because it is related to the treatment task (e.g., written output) but was not specifically addressed in treatment (i.e., treatment never directly addresses phoneme to grapheme conversion). At pre-treatment four control tasks were completed on separate visits over two weeks and all participants demonstrated stable or declining performance.

Discourse Tasks

All discourse tasks were administered at pre-/post-treatment and maintenance testing. The stimuli from the Discourse Comprehension Test (DCT: Brookshire & Nicholas, 1997) was implemented as a measure of story retelling (Doyle, et al., 1998). The DCT includes 12 pre-recorded stories that are matched for length, complexity, and word frequency; however, to ease the burden of testing, only eight stories were used for retelling. Participants listened to the stories, answered eight yes/no questions about the story content, heard the stories again and then retold the stories. Participants retold four of the stories verbally (set A) and four of the stories in writing (set B).

Additional discourse tasks included stimuli and protocols from Nicholas and Brookshire (1993). The stimuli include single picture descriptions, six-panel picture descriptions, procedural

discourse prompts and two requests for personal information; however, procedural discourse was not collected for this study. Ulatowska et al. (1990) noted that there are substantial differences between procedural discourse and other discourse types regarding information content, communicative purpose, and structure. Procedural discourse may consist only of a series of steps that are action oriented and, as a result, the measures selected to evaluate change in discourse for this study are not the most appropriate to evaluate procedural discourse. Therefore, the N&B procedural discourse prompts were not included in the protocol, but the remaining stimuli were. Participants were asked to produce half of the N&B discourse prompts verbally (i.e., four plus one practice) and half in writing (i.e., four plus one practice). In total participants described two single pictures in writing and two verbally, one six panel picture in writing and one verbally, and one personal narrative in writing and one verbally.

Probe measures. Probe measures were developed in the Aphasia and Bilingualism Research Lab at Teachers College, Columbia University. These measures were derived from abridged novel news articles. Probe articles were between 200 and 250 total words and were written at the sixth grade level based on the Flesch Kincaid scale, which uses sentence length and word length to determine the approximate grade level in which text should be understandable (Kincaid, et al., 1975). They were primarily obtained from websites with abridged news articles such as <https://newsela.com> and then modified to meet reading level and length requirements. Modifications included decreasing sentence complexity, passage length and removing ambiguous temporal information (e.g., phrases like *on Monday, last week*, etc.). During probe administration, the clinician instructed the participant to “read the article twice and then you will write a summary of what you have read”. After the participant indicated they were done reading the clinician said “now I want you to write a summary of what you just read the best you can.”

The participant was given as much time as they needed read the article and produce their summary. Participants completed four summarization probes during pre-treatment assessment, and the same four summarization probes were administered during post-treatment and maintenance assessment periods. This methodology represents a modification from study one in which approximately 16 individual probes were administered using 16 different articles. In attempt to reduce variability, the four pre-treatment probes were repeated at post-treatment and maintenance time points. Treatment probes were eliminated to reduce repeated exposure to the stimuli. See Table 4.2 for a comparison of probe administration times across studies.

Table 4.2.

Number of Summarization Probes Administered Throughout Treatment Phases in Study 1 and 2

Study	Pre-treatment	Treatment	Post-treatment	Maintenance
Study 1	4 (novel)	5-6 (novel)	3 (novel)	2 (novel)
Study 2	4	0	4 (repeated)	4 (repeated)

Data Recording

Each assessment and treatment session was audio and video recorded for the purposes of data collection and treatment reliability.

Transcription

Trained research assistants or the primary investigator completed orthographic transcription using audio and video recordings of discourse sampling. Utterances were broken into C-units, which are defined as a main clause with any subordinate clauses (Loban, 1976). Transcription included pauses of greater than or equal to two seconds. Mazes were also included and consisted of filled pauses (e.g. um, uh, eh) and false starts (e.g. d*, g*, thr*). Point-by-point transcription reliability was conducted on words, pauses, and utterance breaks. To calculate the reliability, the total number of agreements was divided by the total possible. For P100

transcription reliability was completed for 40% of transcripts with reliability of 93.33%. For P600 reliability was completed for 20% of transcripts with reliability of 92.82%. Transcription disagreements were resolved by referring to the original video and/or audio recordings.

All transcripts were coded for the micro and macrolinguistic measures which are described below.

Discourse Analysis

Microstructure. The microlinguistic discourse measures included percent correct information units, percent complete utterances and percent of grammatically complex sentences. *Percent Correct Information Units* are words that are intelligible in context, accurate in relation to the stimuli or topic and relevant to and informative about the content of the picture/story/topic (Nicholas & Brookshire, 1993). The Correct Information Unit (CIU; Nicholas & Brookshire, 1993) is one of the most widely researched and used content measures. Nicholas and Brookshire (1993) reported the reliability, session-to-session stability, and sensitivity of the CIU by examining the discourse of 20 non-brain-damaged adults and 20 people with aphasia using their 12 stimuli (i.e. two practice, four single pictures, two picture sequences, two requests for personal information, two requests for procedural information). Additional work by Brookshire and Nicholas (1994) determined the required speech sample size and test-retest stability of their stimuli and CIU measure. Their findings revealed that the test-retest stability of their elicitation procedure was high when four to five samples are collected for a total of 300-400 words. Number of CIUs and derivations of this measure (e.g. %CIUs, CIUs per minute) have been proven to be sensitive to change after treatment (Edmonds, et al., 2009; Rogalski & Edmonds, 2008; Antonucci, 2009).

Complete Utterances are utterances that contain subject + verb + (object) structure and

are also relevant to the topic and not repeated (CU; Edmonds, et al., 2009). Grammatical, morphological, and phonemic errors within a sentence are not penalized in complete utterance scoring. The CU measure with its combination of relevance and basic sentence structure provides an added level of analysis that is especially useful in examining the effects of treatments that target sentence or discourse level language. The CU has been successfully used to measure change in the discourse of people with aphasia in treatment studies since it was first defined (Edmonds, 2016; Edmonds, et al., 2009; Furnas & Edmonds, 2014; Edmonds, et al., 2014). Additionally, percent CUs was a sensitive measure of improvement for the participants in study one (Chapter 2) (Obermeyer & Edmonds, 2016).

Grammatical Complexity was rated as described by Altman, et al. (2012) on a scale of complexity defined thus: 1: incomplete sentence, 2= simple and complete (contains all required elements), 3= complex structure with incomplete subordinate or coordinate clause, 4= complete coordinate structure, 5= complete containing a subordinate structure. Since utterances were defined using C-unit procedures, an utterance with complete coordinate structures was broken into two utterances. When complete coordinate structures were encountered, the first clause would not be coded for grammatical complexity and the second would be coded as a 4, indicating complete coordinate structure. For example, the utterance (1) *The boy is running with his kite* (2) *but the dog is about to catch him.* would be broken into two C-units, because the sentence has complete coordinate structure. The first utterance would not be scored, and the second utterance's grammatical complexity would be rated a 4, versus both utterances being scored a 2 (i.e., simple and complete sentence structure). Utterances combined with the coordinating conjunction "and" were not coded as 4, due to the over reliance on "and" as a filler between utterances.

Grammatical complexity was added as an outcome measure in this study. Since the participants in study one made strong gains at the sentence level, this measure provided further insight into the complexity of the sentences produced. Additionally, this grammatical complexity rating has been sensitive to change after treatment in people with aphasia (e.g. Kempler & Goral, 2011). See Table 4.3 for description of microlinguistic discourse measures. See Appendix B for examples of microlinguistic codes.

Table 4.3.

Microlinguistic Outcome Measures

<u>Outcome</u>	<u>Definition</u>
%CIUs	Total number of words that are accurate and relevant in relation to the context divided by the total number of words
%CUs	Total number of utterances that are relevant and have subject+verb+(object) structure divided by the total number of utterances
Grammatical complexity	Percentage of utterances which were grammatically complex sentences (rated 4 or 5) over the total number of utterances produced. Utterances are rated on a scale of 1-5 with 1 defined as an incomplete sentence and 5 as a complete sentence containing a subordinate structure

Note. %CIUs= percent complete information units; %CUs= percent complete utterances

Macrostructure. Macrolinguistic measures were coded to capture the production of essential information and topic maintenance. *Main concepts* are story propositions that accurately and completely contain all essential information (Nicholas & Brookshire, 1995). For the summarization probes, main concepts were determined by consensus between two of three people with graduate training in speech language pathology (following the example of Wright et al., 2005). The summarization probes each had six-seven main concepts. Main concepts for the story retelling stimuli (DCT) were derived from the main idea questions in The Discourse Comprehension Test. There were four main ideas/concepts for each stimulus. For implied main ideas, the implied information was accepted as correct or the stated information from which it was extrapolated was accepted. For example, one of the story retell implied main concepts was “Harry didn’t make it to the cleaners”. In main concept scoring the implied main idea would be

accepted as complete or the stated information from which the implied main concept was extrapolated from would be accepted as complete (e.g. Harry was in a hurry to get to the cleaners because they were going to close in a few minutes, he got pulled over). Main concepts were also evaluated for four of the Nicholas & Brookshire stimuli (1993) using the main concepts defined by Capilouto and colleagues (2005 & 2006). Specifically, main concepts were evaluated for the following pictures; birthday (written, N=5), fight (written, N=7), cat in tree (spoken, N=4), directions (spoken, N=8).

Main concepts were scored as complete (score of 1) if they contained all the predetermined information or incomplete (score of .5) if only part of the information was present or correct. Additionally, if participants conveyed a complete main concept over two utterances, each utterance would be scored as .5 for a total score of 1. For example, one main concept for the cat in tree picture is *the dog chased the cat up the tree*. When conveyed over two utterances (1) *The cat is in the tree*. 2) *It probably went up there to get away from the dog*, it would get a total score of 1 for conveying the complete main concept.

Global coherence was evaluated using a four-point scale (Wright & Capilouto, 2012; Wright, et al., 2013; Wright, et al., 2014). Each utterance was scored based on how related it was to the discourse topic on a scale of one to four (see Table 4.3). Wright and colleagues (2013) evaluated the reliability and construct validity of the four-point scale with a five-point scale (Glosser & Deser, 1991) in a group of 50 neuro-typical adults. Their findings revealed that the four-point global coherence scale had high reliability and construct validity. A global coherence score was calculated based on the numerical value associated with each utterance, which was totaled for the discourse sample and then divided by the total number of utterances in the discourse transcript. See Table 4.4 for definitions of macrolinguistic measures and Appendix C

for examples of macrolinguistic codes. See Table 4.5 for a summary of all outcome measures.

Table 4.4.

Macrolinguistic Outcome Measures

<u>Outcome</u>	<u>Definition</u>	<u>Rating Scale</u>
% Main Concepts	Number of main concepts conveyed divided by total number of main concepts identified in the text	1= complete main concept 0.5= incomplete main concept
Global coherence (Wright et al., 2013)	Global coherence derived from the total global coherence scores for each discourse sample divided by the total number of utterances. Global coherence is determined by the degree to which each utterance is related to the global discourse topic	4=definite relations between utterance and main detail of the topic 3=utterance is related to the topic but may include tangential information or is related to the topic but is missing information that must be inferred. 2= utterance is remotely related to the topic or references an unimportant/non-critical component of the stimulus. 1= no relationship between utterance and topic

Discourse Coding

Trained research assistants completed discourse coding for each discourse measure. They were aware they were coding discourse samples from a treatment study but were blind to testing period (e.g. pre-treatment, post-treatment or maintenance). Point-by-point reliability was completed by the primary investigator for each discourse measure on 40% of the transcripts. Reliability for P100 was 99.49% for words, 90.21% for CIUs, 88.96% for CUs, 88.26% for grammatical complexity, 87.56% for global coherence and 91.24% for Main Concepts. Reliability for P600 was 98.77% for words, 92.06% for CIUs, 88.60% for CUs, 90.01% for Grammatical complexity, 90.01% for global coherence, and 90.32% for Main Concepts. Coding discrepancies were discussed between the original coder and the reliability coder. If an agreement could not be reached, a third trained coder was asked to resolve the issue.

Table 4.5.

Frequency and Time of Testing for Outcome Measures

Aim Addressed	Outcome Measures	Number of times Tested		
		Pre-tx	Post-tx	Maint
Research Questions 1 and 2 Tasks				
Written article summarization	1.) %Correct Information Units	4	4	4
	2.) %Complete Utterances			
	3.) %Grammatically complex			
	4.) %Main Concepts			
	5.) Global Coherence			
Control Task, nonwords writing to dictation from John's Hopkins Dyslexia and Dysgraphia battery	Percent accuracy (N=34)	4	4	4
Nicholas & Brookshire (1993) discourse (static and sequential pictures, and personal discourse) written and spoken modalities	1.) %Correct Information Units	1	1	1
	2.) %Complete Utterances			
	3.) %Grammatically complex			
	4.) %Main Concepts			
	5.) Global Coherence			
Story retelling task from Discourse Comprehension Test (Brookshire & Nicholas, 1997)-written and spoken modalities	1.) %Correct Information Units	1	1	1
	2.) %Complete Utterances			
	3.) %Grammatically complex			
	4.) %Main Concepts			
	5.) Global Coherence			
Research Question 3 tasks				
Confrontation naming of 162 objects and 100 actions (written and spoken modality) using the Object and Action Naming Battery.	1.) percent correct spoken objects	1	1	1
	2.) percent correct written objects			
	3.) percent correct spoken actions			
	4.) percent correct written actions			
Production of 20 sentences, first via speaking and then in writing using the Sentence Production Test	1.) Sentence score which is the number of correct sentence component divided by the total possible.	1	1	1
	2.) Open class score which is the number of correct content words divided by the total possible.			
Functional Communication ratings from a communication partner and self-report	1.) Communicative Effectiveness Index (communication partner report)	1	1	1
	2.) Aphasia Communication Outcome Measure (self-rated)			
Research Question 4 tasks				
Severity ratings from the Cognitive-Linguistic Quick Test in each cognitive domain	1.) Attention	1	1	1
	2.) Memory			
	3.) Language			
	4.) Executive Function			
	5.) Visuospatial Skills			

Therapy Protocol

Treatment materials were obtained from current event websites such as www.newsela.com. Before treatment was initiated, the clinician asked participants to identify topics that were of interest to them. Each participant's preferences and interests were then taken into consideration during selection of treatment materials. In addition, participants were provided with two-three article choices at the beginning of each session to promote engagement and discourse saliency. During the first treatment step, participants listened to abridged versions of news stories written at the sixth-grade reading level. Participants then read a segment (one-three sentences) twice with the intent to summarize, and identified key words in the segment. Once key words were identified, the participant wrote/typed them and compared them with the keywords that the clinician had identified. If there was a disagreement between the clinician and participant, it was resolved through discussion of the content and what words were the most important to include. The participant was then given an opportunity to look at their key words and plan a verbal summary of the material. Once ready, the key words were covered/removed and the participant produced a verbal summary of the segment. The same step was completed (look at key words, plan, cover keywords, summarize) in writing. During summarization, the participant was prompted to follow prescribed constraints (no nonspecific words (e.g., pronouns), stay on topic). Both participants demonstrated word retrieval deficits in discourse which sometimes resulted in abandoned utterances; therefore, the constraint "use complete sentences" was added. These steps were repeated until the entire article was summarized. Then the participant reread the article and summarized the article in its entirety, verbally and in writing. The last step required the participants to rate the completeness of their summary on a scale of 1-5 with a score of 1 being "not at all complete" and a score of 5 representing "entirely

complete”. The purpose of this step was for the participant to focus on the content of their discourse in relation to the article. See Table 4.6 for detailed protocol.

The treatment protocol reported here is similar to the protocol carried out in study one. Two changes were made to refine the protocol and maximize treatment effects. The first was the removal of key words during spoken and written summarization. During study one, participants could use the key words they had written/typed to assist in constructing their spoken and written summaries. The decision to remove keywords while participants summarized material was made to increase the opportunities for participants to independently retrieve lexical items versus copying them from their key word list. Removing the keywords also provided an additional opportunity for participants to plan their summaries. The second change to the treatment protocol was the addition of a homework task which is detailed below. The homework task was added to encourage generalization and writing in the home environment.

Homework activity. Each week participants completed a homework activity. Each week, the participants selected an article that had not been summarized previously. The following instructions were provided in writing and made clear to the participants in person before they took the work home (see Appendix D for full instructions). Participants were instructed to read the article, identify the key words and then write a summary of what they read implementing the same constraints used in the therapy sessions (e.g. use specific words, stay on topic, use complete sentences). During homework, participants could refer to the written text (which they could not do during therapy). This accommodation was made to increase the likelihood that participants would write correct words and demonstrate better understanding of the text while completing their summaries independently. During the first therapy session of the week, the clinician and participant reviewed the homework summary together and the clinician provided

feedback about whether the participant followed their constraints and how complete the summary was.

Treatment fidelity. A trained research assistant completed treatment fidelity. The research assistant was provided with a checklist of the treatment steps and then watched video recorded treatment sessions and identified if each step was completed in the session. Treatment fidelity was completed for 50% of treatment sessions for both P100 and P600. Treatment fidelity was 97% for P100 and 98% for P600.

Data Analysis

For all discourse measures, except global coherence, a change of 10 percentage points or greater was interpreted as clinically significant. This benchmark was selected a priori based on prior literature (Edmonds, et al., 2009) which identified a change of 15 percentage points or greater to be clinically significant. For the purposes of this study, 10 percentage points was selected since the participants had mild aphasia and relatively high pre-treatment abilities. Additionally, many written discourse measures are higher at pre-treatment than spoken discourse measures (Obermeyer & Edmonds, 2015), therefore, a change of 10 percentage points was deemed more appropriate for capturing change in this population across discourse types, tasks and modalities. Additionally, total words and total utterances are reported for each discourse task to assist in interpreting %CIUs and %CUs.

Global coherence was interpreted using data for 40 healthy adults aged 70-87 years reported by Wright et al. (2014). A change of 2 standard deviations or greater was identified as clinically significant for both written and spoken data. Wright and colleagues reported a standard deviation of 0.22 based on the single picture Nicholas and Brookshire stimuli (1993) and 0.18 for a story telling task. Therefore, a change of 0.44 in average global coherence was considered

significant for N&B stimuli and a change of 0.36 was considered significant for the story retelling task.

For summarization probe measures and control probes, percentage accuracy and effect sizes are reported. Effect sizes were calculated using a variation of Cohen's d reported by Beeson and Robey (2006) and Busk and Serlin (1992). Effect sizes were calculated by averaging performance for each variable at pre-treatment, post-treatment and maintenance. To calculate the pre- to post-treatment effect, the pre-treatment mean is subtracted from the post-treatment mean and that value is divided by the standard deviation of the pre-treatment variable following this formula: $d = \bar{X}_{a2} - \bar{X}_{a1} \div S_{a1}$. Effect sizes were interpreted using the benchmarks reported by Robey, Schultz, Crawford and Sinner (1999), which have been applied to written outcomes at the single word level (Beeson & Robey, 2006). Those benchmarks are 2.6, 3.9, and 5.8 which represent a small, medium and large effect respectively. To the knowledge of the primary investigator, there are no effect size benchmarks for discourse level written language.

Additionally, the published bench marks are not designed to interpret generalization measures or novel stimuli such as the probes used in this study (e.g. Beeson & Robey, 2006; Kendall et al., 2008). Therefore, the effect sizes reported here are used in addition to the a priori benchmarks established for the other discourse measures (i.e. change of 10 percentage points, or two standard deviations).

For research question three which evaluated confrontation naming, sentence production and functional communication the benchmarks were used to interpret meaning full improvement. A significant increase in confrontation naming was defined as an increase of two or more standard deviations on the Object and Action Naming Battery (Druks & Masterson, 2000) (i.e. SD objects = 2.72, SD actions = 4.1). A significant improvement on the SPT (Wilshire, et al.,

2014) was defined as a change of 10 percentage points on the complete sentence score and/or the open class percentage score. Functional communication was assessed using the ACOM (Hula, et al, 2015) and the CETI (Lomas, et al., 1989). A clinically significant improvement on the ACOM was defined as an increase of one standard deviation (10 pts) or greater. A significant improvement on the CETI (Lomas, et al, 1998) was defined as a significant result on the Wilcoxon Rank Test ($p < 0.05$) when comparing pre-treatment and post-treatment results.

Table 4.6.

Attentive Reading with Constrained Summarization-Written (ARCS-W) Treatment Steps

Treatment Step	Clinician Action	Participant Action
Review homework (during the first session of the week)		
Step 1	Read the entire article	Read 1-3 sentences, twice for comprehension
Step 2	Write down key words in the segment	Identify and write down key words
Step 3	Provide feedback on the key words identified	Compare key words with the clinician's identified
Step 4	Remove keywords when the participant is ready to summarize	Participant will use key words to plan their verbal summary
Step 5	Clinician will provide feedback regarding constraints, and content (keywords)	Verbally summarize the segment, while following constraints
Step 6	Remove key words when participant is ready to summarize	Participant will use key words to plan their written summary
Step 7	Clinician will provide feedback regarding constraints and content.	Summarize what they read/heard in writing and then read it to the clinician and check for errors
	Repeat steps 2-5 until each segment of the article has been summarized	
Step 8		Listen to/read the entire article
Step 9	Provide feedback on spoken and written summary	Participant will summarize the entire article verbally and in writing without keywords.

Note. Treatment steps in boldface indicate a change from the protocol in study 1.

Chapter 5: Results

P100: Research question 1: Effect of ARCS-W on written discourse

Written N&B (1993). Relevant words (%CIUs) were high at pre-treatment (84.94%) and did not improve at post-treatment (88.54%) or maintenance (76.42%), but total words did increase (pre-treatment=166, post-treatment=253, maintenance=318). Similarly, %CUs did not increase from pre-treatment (80.0%) to post-treatment (77.5%) or maintenance (75.0%), and total number of utterances did (25 pre-treatment, 40 post-treatment, 40 maintenance). Percent of grammatically complex utterances was at 20% pre-treatment, and then decreased at post-treatment (8.0%) and maintenance (14.29%).

Both macrolinguistic measures improved. Global coherence increased from 2.77 to 3.34, which was maintained at 3.31 one-month after treatment. The percent of main concepts conveyed also improved from 41.67% at pre-treatment to 66.67% post-treatment and continued to improve to 79.17% at maintenance. See table 5.1.

Written story retell. Relevant words (%CIUs) were high at pre-treatment (83.12%) and did not improve (80.46% post-treatment, 80.19% maintenance), but total words increased (314 pre-treatment, 346 post-treatment, 418 maintenance). Percent CUs did not improve (67.39% pre-treatment, 73.47% post-treatment, 75.0% maintenance) and total utterances did not increase (46 pre-treatment, 48 post-treatment, 49 maintenance). The percent of grammatically complex utterances did not improve from pre- to post-treatment (28.57-30.95%) but did increase at maintenance (42.86%).

In regard to macrolinguistic measures, global coherence was high at pre-treatment (3.45/4.0) and did not change at post-treatment (3.49) or maintenance (3.4). Percent of main concepts did not improve from pre-treatment to post-treatment (50.0-56.25%), but did increase

when comparing pre-treatment (50.0%) to maintenance (68.75%). See Table 5.1.

Table 5.1.

P100 Written Discourse Outcomes from Pre- to Post-Treatment and at Maintenance

Task	Pre-tx	Post-tx	Pre-to Post Change	Maint	Pre-to Maint Change
Written N&B (1993)					
Total Words	166	253	+87	318	+152
%CIUs	84.94%	88.54%	+3.6%	76.42%	-8.52%
CIUs/Min	7.18	8.14	+0.96	6.63	-0.55
Total Utterances	25	40	+15	40	+15
%Complete Utterances	80.0%	77.5%	-2.5%	75.0%	-5.0%
%GramComplex	20.0%	8.0%	-12.0%	14.0%	-6.0%
%Main Concepts	41.67%	66.67%	+25.0%	79.17%	+37.5%
Global Coherence	2.77	3.34	+0.57	3.31	+0.54
Written Story Retell					
Total Words	314	346	+32	418	+104
%CIUs	83.12%	80.64%	-2.48%	80.19%	-2.93%
CIUs/Min	7.18	7.53	+0.35	7.92	+0.74
Total Utterances	46	49	+3	48	+2
%Complete Utterances	67.39%	73.47%	+6.08%	75.0%	+7.61%
%GramComplex	28.57%	30.95%	+2.38%	42.86%	+14.29%
%Main Concepts	50.0%	56.25%	+6.25%	68.75%	+18.75%
Global Coherence	3.45	3.49	+0.04	3.4	-0.05

Note. Pre-tx=pre-treatment, post-tx=post-treatment, maint=maintenance; %CIUs=percent of correct information units (Nicholas & Brookshire, 1993), %GramComplex= percent of grammatically complex utterances (Altman, Goral & Levy, 2012).

Change of 10 percentage points from pre- to post-treatment are in boldface, except for global coherence in which a change of two standard deviations or more are in boldface (Wright et al., 2014).

Written summarization probes. Here the average of the four individual probe articles completed during pre-treatment, post-treatment and maintenance are reported for all discourse measures. At pre-treatment %CIUs were at 51.82% (standard deviation: 9.32) and 137 total words were produced. At post-treatment %CIUs were 59.46% with a corresponding effect size of 1.07 and 185 total words. At maintenance, %CIUs were 62.93%, which met our percentage change criteria (10 percentage points) but did not produce a significant effect size (1.19). See Figure 5.1. Additionally, total words increased to 205 (See Figure 5.2). The %CUs did not improve from pre-to post-treatment (32.0-30.43%, $d=-0.188$), but did improve from pre-treatment to maintenance (50.0%) with a change of 18 percentage points (see Figure 5.1). However, the effect size only approached significance ($d=2.35$) (Robey, Shultz, Crawford, &

Sinner, 1999). The total number of utterances produced did not change (see Figure 5.3.). No grammatically complex sentences were produced at pre-treatment with only a slight change at post-treatment (4.34%) and no complex utterances were produced at maintenance (see Figure 5.1) An effect size could not be calculated because no grammatically complex sentences were produced during pre-treatment assessment. Main concepts did not improve from pre-treatment (9.61%) to post-treatment (9.61%) or at maintenance (17.31%). See Figure 5.4. Effect sizes were 0.00 and 1.02, respectively. Global coherence did not improve from pre-treatment to post-treatment (2.48-2.69) with an effect size of 0.58 or at maintenance (2.46, $d = -0.03$). See Figure 5.5.

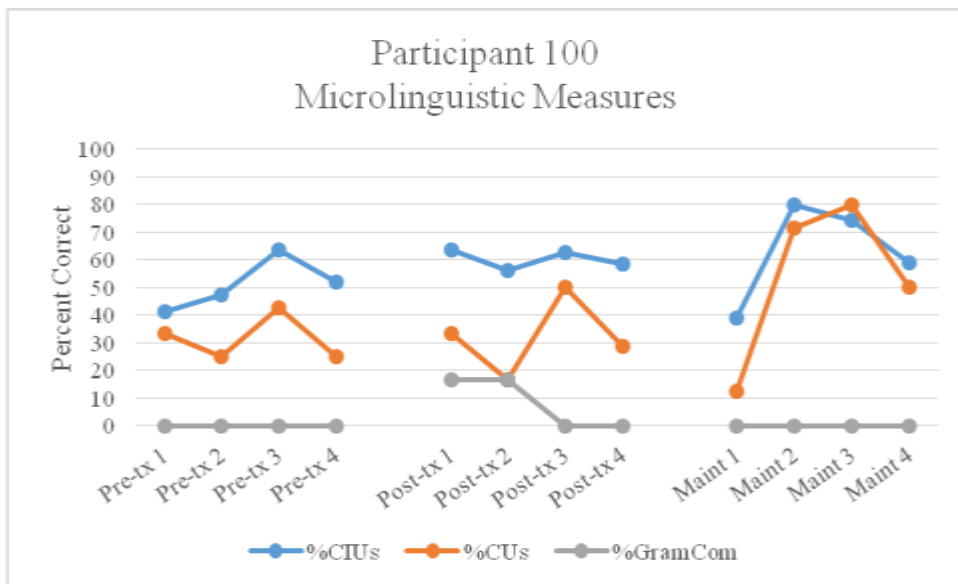


Figure 5.1. P100 microlinguistic outcomes for written summarization probes at pre-treatment, post-treatment and maintenance.
 Pre-tx=pre-treatment; post-tx=post-treatment, maint=maintenance
 %CIUs=correct information units; %CUs=complete utterances; % GramCom=Grammatical Complexity.

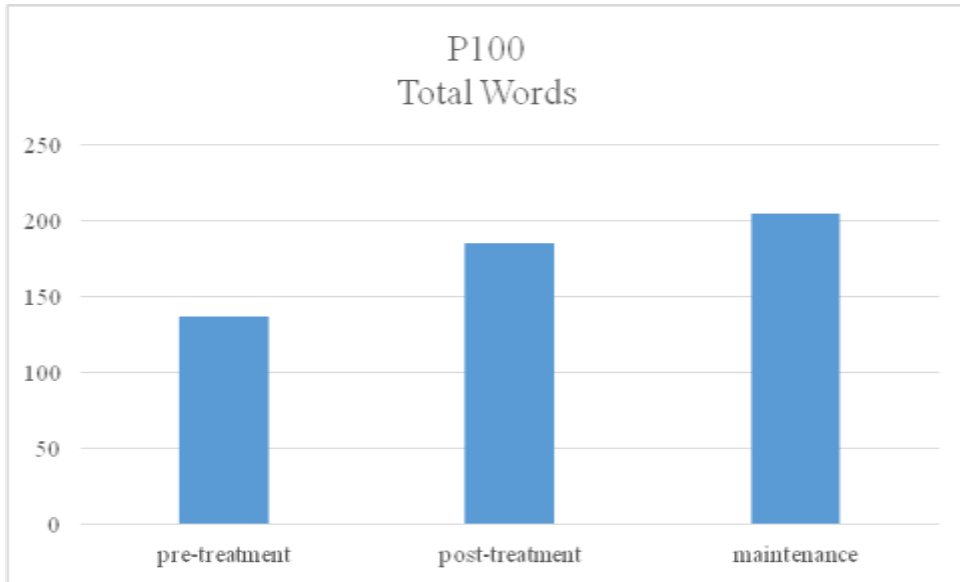


Figure 5.2. Total words produced by P100 in written summarization probes at pre-treatment, post-treatment and maintenance.



Figure 5.3. Total utterances produced by P100 in written summarization probes at pre-treatment, post-treatment and maintenance.

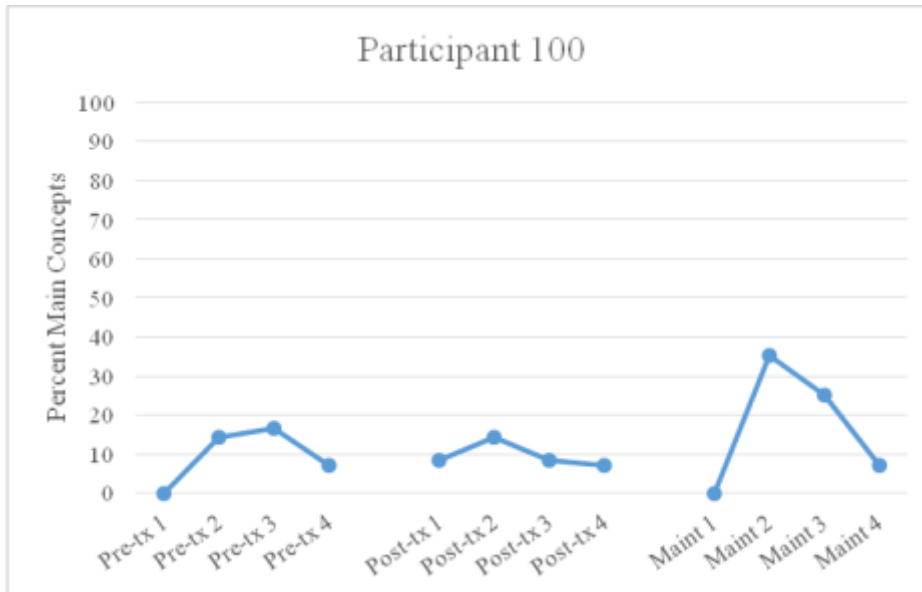


Figure 5.4. P100 percent main concepts for written summarization probes at pre-treatment, post-treatment and maintenance.
Pre-tx=pre-treatment; post-tx=post-treatment; maint=maintenance

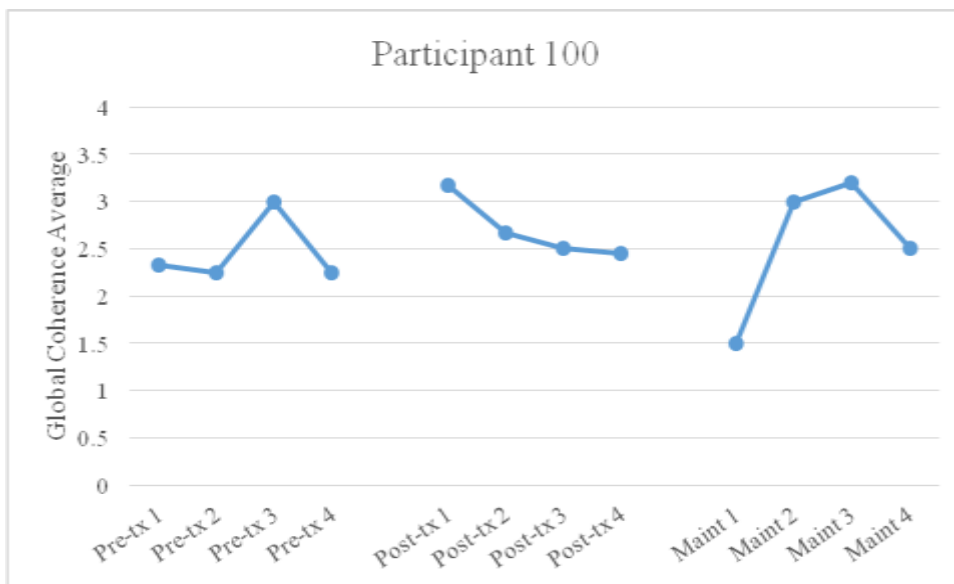


Figure 5.5. P100 global coherence on written summarization probes at pre-treatment, post-treatment and maintenance.
Pre-tx=pre-treatment; post-tx=post-treatment; maint=maintenance

Control task. P100's pre-treatment accuracy (averaged over four visits) was 25.03% on nonword writing to dictation (N=34) (Goodman & Caramazza, 1986) and post-treatment accuracy was 23.55% with a corresponding effect size of -0.507. Average accuracy at maintenance was 25.75% with an effect size of 0.246. These results indicate that there was not

treatment effect on the control task.

P100: Research Question 2: Effect of ARCS-W on Spoken Discourse

Spoken N&B (1993). No improvement was observed in %CIUs (46.24-50.45-48.71%) or %CUs (57.58-62.16-64.71%) from pre-treatment to post-treatment or at maintenance. Total words increased from pre-treatment to post-treatment (744-1100), but decreased at maintenance (698). Similarly, P100 produced more utterances at post-treatment (111) than at pre-treatment (66), but this increase was not maintained one month after treatment (51). The percent of grammatically complex utterances did not increase from pre- to post-treatment (5.88-8.91%) but did increase at maintenance (22.22%).

Global coherence decreased from pre-treatment (2.92) to post-treatment (2.16) and returned to pre-treatment levels at maintenance (2.98). The percent of main concepts conveyed did not increase from pre-to post-treatment (45.83-41.67%), but did when comparing pre-treatment to maintenance assessment (66.67%). See table 5.2.

Spoken story retell. Relevant words (%CIUs) and total words increased from pre-treatment (%CIUs=46.01%, Total words=602) to post-treatment (%CIUs=64.29%, Total words=665), but were not maintained at post-treatment levels (%CIUs=52.95%, Total words=644). A similar pattern was observed with %CUs which increased from 52.94% at pre-treatment to 64.29% at post-treatment and went to 59.68% at maintenance. No change was observed in total utterances (pre-treatment=68, post-treatment=70, maintenance=62). The percent of grammatically complex utterances did not increase from pre-to post-treatment (22.95-29.31%), but did one month after treatment (42.31%).

Regarding macrolinguistic measures, global coherence increased from pre-treatment

to post-treatment (2.89-3.25) but was not maintained (3.15) one month post-treatment.

P100 conveyed a higher percentage of main concepts at post-treatment (65.3%) than at pre-treatment (53.13%), which was maintained (65.63%). See table 5.2.

Table 5.2.

P100 Spoken Discourse Outcomes from Pre- to Post-Treatment and Maintenance Assessment.

Task	Pre-tx	Post-tx	Pre-to Post Change	Maint	Pre-to Maint Change
Spoken N&B (1993)					
Total Words	744	1100	+356	698	-46
%Correct Information Units	46.24%	50.45%	+4.21%	48.71%	+2.47%
CIUs/Min	18.11	20.19	+2.08	22.62	+4.51
Total Utterances	66	111	+45	51	-15
%Complete Utterances	57.58%	62.16%	+4.58%	64.71%	+7.13%
%Grammatically Complex	0.06%	0.09%	0.03%	22.22%	+22.16%
%Main Concepts	45.83%	41.67%	-4.16%	66.67%	+20.84%
Global Coherence	2.92	2.16	-0.76	2.98	+0.06
Spoken Story Retell					
Total Words	602	665	+63	644	+42
%Correct Information Units	46.01%	60.75%	+14.74%	52.95%	+6.94%
CIUs/Min	18.32	26.93	+8.61	20.0	+1.68
Total Utterances	68	70	+2	62	-6
%Complete Utterances	52.94%	64.29%	+11.35%	59.68%	+6.74%
%Grammatically Complex	22.95%	29.31%	+6.36%	42.31%	+19.36%
%Main Concepts	53.13%	65.63%	+12.5%	65.63%	+12.5%
Global Coherence	2.88	3.25	+0.37	3.15	+0.27

Note. Pre-tx=pre-treatment, post-tx=post-treatment, maint=maintenance.

Change of 10 percentage points from pre- to post-treatment are in boldface, except for global coherence in which a change of two standard deviations or more are in boldface (Wright et al., 2014).

P100: Research Question 3: Effect of ARCS-W on Confrontation Naming, Sentence

Production and Functional Communication

P100 demonstrated a significant improvement on confrontation naming of written and spoken nouns. Pre-treatment he named spoken nouns with 88.9% (72/81) accuracy which improved to 96.3% (78/81) at post-treatment and 98.7% (80/81) during maintenance assessment and met the criteria for improvement (greater than 2 stand deviation change, 1 SD=2.72). At maintenance, P100's spoken confrontation naming accuracy was within normal limits (Druks & Masterson, 2000). Written confrontation naming accuracy of nouns went from 76.5% (62/81) at pre-treatment to 82.7% (67/81) at post-treatment which was not significant. However, the change

from pre-treatment to maintenance (91.4%-74/81) did reach the benchmark for improvement. Spoken confrontation naming of actions was highly accurate at pre-treatment (96%), post-treatment (90%), and maintenance (96%), with pre-treatment and maintenance accuracy rates reaching within normal limits (Druks & Masterson, 2000). Written confrontation naming of actions did not increase significantly and was at 78% (39/50) pre-treatment, 82% (41/50) at post-treatment and 88% (44/50) at maintenance.

No significant change was observed regarding sentence production in speaking or writing. Pre-treatment spoken sentence production accuracy was 78.3% which included percentage accuracy for open class words, closed class words, and word order. When content words alone were evaluated accuracy was 80% pre-treatment. Post-treatment sentence production accuracy was 77.5% for all sentence components and 74.6% for content words/open class words. At maintenance, overall sentence accuracy was 81.9% and accuracy of open class words was 82.5%. Pre-treatment written sentence production was lower at 72.9% for overall accuracy and 73.8% accurate when evaluating open class words. At post-treatment, overall sentence accuracy was 77.0% and open class word accuracy was 71.3%. At maintenance sentence accuracy was 81% and open class word accuracy was 77.1%.

Functional communication was evaluated via communication partner report and self-report. Communication partner report was evaluated with the CETI (Lomas, et al., 1989) at pre-treatment and post-treatment. P100's communication partner did not rate his functional communication significantly better on the CETI (Lomas, et al., 1989) based on the Wilcoxon Rank Test ($p=.667$). However, she did rate his communication ability higher on a few items, such as having a one-on-one conversation (7.2/10-8.6/10), and describing or discussing something in depth (6.2/10-8.8/10). P100's self-rated functional communication (ACOM; Hula,

et al., 2015) t-score was 56.57 at pre-treatment and increased to 69.76 at post-treatment, which is an increase of greater than one standard deviation (10 points), and met the criteria for improvement. At maintenance, P100's t-score was 60.6, which did not maintain improvement at post-treatment levels but was still more than twice the standard error at pre-treatment (1.5). See Table 5.5 for results.

P100: Research Question 4: Effect of ARCS-W on Cognitive-Linguistic Skills

P100's composite score on the CLQT (Helm-Estabrooks, 2001) was within normal limits at pre-treatment, therefore, this question was not evaluated. See Table 5.6 for detailed results.

P600: Research Question 1: Effect of ARCS-W on Written Discourse

Written N&B (1993). P600 produced a high percentage of relevant words (%CIUs) at pre-treatment and post-treatment (pre-treatment=84.11%, post-treatment=86.07%) with limited total words produced at both time points (pre-treatment=107, post-treatment=122). From pre- to post-treatment, %CUs went from 66.67-76.47%, but did not meet our criteria for improvement. No change in total number of utterances produced (15 pre-treatment, 17 post-treatment). At pre-treatment, P600 did not produce any grammatically complex utterances, which increased to 13.33% at post-treatment.

Both macrolinguistic measures improved with average global coherence increasing from 3.27 at pre-treatment to 3.75 at post-treatment. Percent of main concepts conveyed increased from 37.50% at pre-treatment to 54.17% at post-treatment. See Table 5.3.

Written story retell. P600 increased relevant words (%CIUs) from 74.80% at pre-treatment to 84.80% at post-treatment and total number of words increased from 123 at pre-treatment and 171 at post-treatment. No increases were observed in the remaining microlinguistic measures of %CUs (71.43-76.47%), total utterances (14-17), or percent of

grammatically complex utterances (7.69-5.88%).

Average global coherence increased from pre- to post-treatment (3.07-3.65). P600 did not convey a higher %MCs when comparing pre- to post-treatment (34.38-40.63%). See Table 5.3.

Table 5.3.
P600 Written Discourse Outcomes from Pre-to Post-Treatment

Task	Pre-tx	Post-tx	Pre-to Post Change
Written N&B (1993)			
Total Words	107	122	+15
%Correct Information Units	84.11%	86.07%	+1.96%
CIUs/Min	3.29	2.73	-0.56
Total Utterances	15	17	+2
%Complete Utterances	66.67%	76.0%	+9.33%
%Grammatically Complex	0.00%	13.33%	<i>13.33%</i>
%Main Concepts	37.5%	54.17%	<i>+16.67%</i>
Global Coherence	3.26	3.75	<i>+0.49</i>
Written Story Retell			
Total Words	123	171	+48
%Correct Information Units	74.80%	84.80%	<i>+10.0%</i>
CIUs/Min	2.54	2.26	-0.28
Total Utterances	14	17	+3
%Complete Utterances	71.43%	76.47%	+5.04%
%Grammatically Complex	0.08%	0.06%	-0.02%
%Main Concepts	34.38%	40.63%	+6.25%
Global Coherence	3.08	3.65	<i>+0.57</i>

Note. Pre-tx=pre-treatment, post-tx=post-treatment, maint=maintenance; Change of 10 percentage points from pre- to post-treatment are in boldface, except for global coherence in which a change of two standard deviations or more are in boldface (Wright et al., 2014).

Written summarization probes. Relevant words increased in regard to our a priori percentage bench mark (change of 10 percentage points or greater) with pre-treatment %CIUs at 60.98% and post-treatment %CIUs at 73.04% (see Figure 5.6), in the context of more total words (pre-treatment=82, post-treatment=115). See Figure 5.7. However, the effect size was not significant ($d=0.89$) due to high variability during pre-treatment assessment (standard deviation=13.84). A similar pattern was observed for %CUs which were at 18.18% pre-treatment and increased to 58.33% at post-treatment (Figure 5.8), with similar total utterances at pre-treatment (11) and post-treatment (12) (Figure 5.6). The effect size for %CUs from pre-to post-

treatment was 1.22 due to extremely high variability at pre-treatment (standard deviation=33.33). P600 did not produce more complex utterances (9.09%, $d=0.0$) (Figure 5.6).

Percent of main concepts conveyed did not improve and were at 3.85% pre-treatment which went to 13.46% at post-treatment, the corresponding effect size was 2.139 (Figure 5.9). Global coherence increased from 2.45 at pre-treatment to 3.27 at post-treatment (Figure 5.10), which was a change greater than 2 standard deviations, compared to those reported by Wright et al. (2014); however, the corresponding effect size of 1.97 was not significant. Based on visual inspection of the figures, all measures demonstrated high variability. However, at post-treatment many measures improved, except for post-treatment probe 3, which was low across measures.

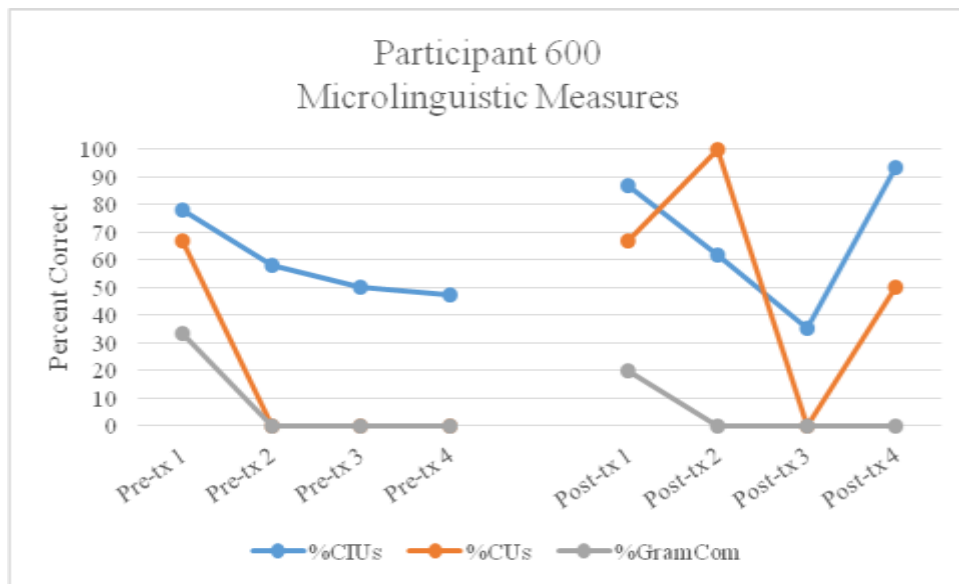


Figure 5.6. P600 microlinguistic outcome measures on written summarization probes at pre-treatment and post-treatment. Pre-tx=pre-treatment; post-tx=post-treatment. %CIUs=correct information units; %CUs=complete utterances; %GramCom=Grammatical complexity.

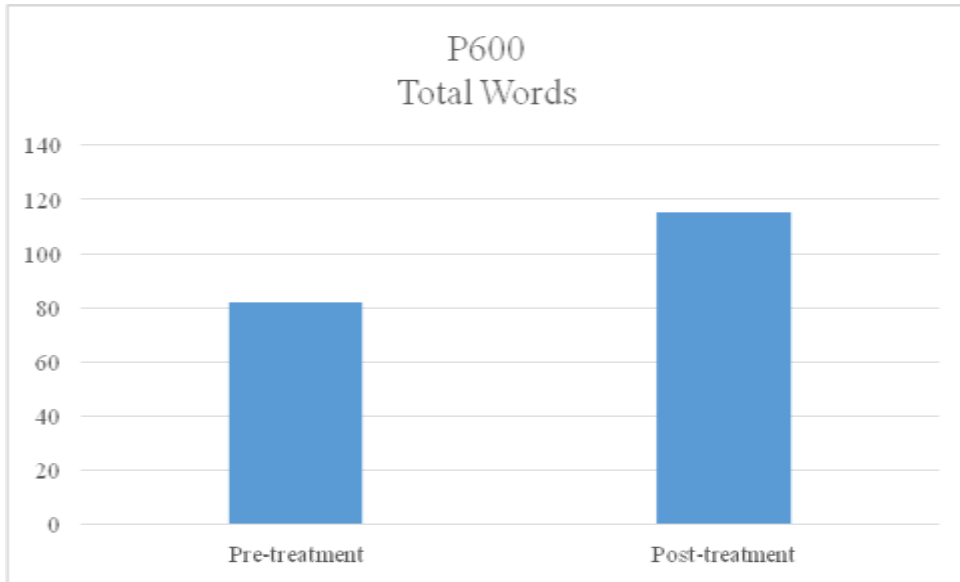


Figure 5.7. Total words produced by P600 in written summarization probes.

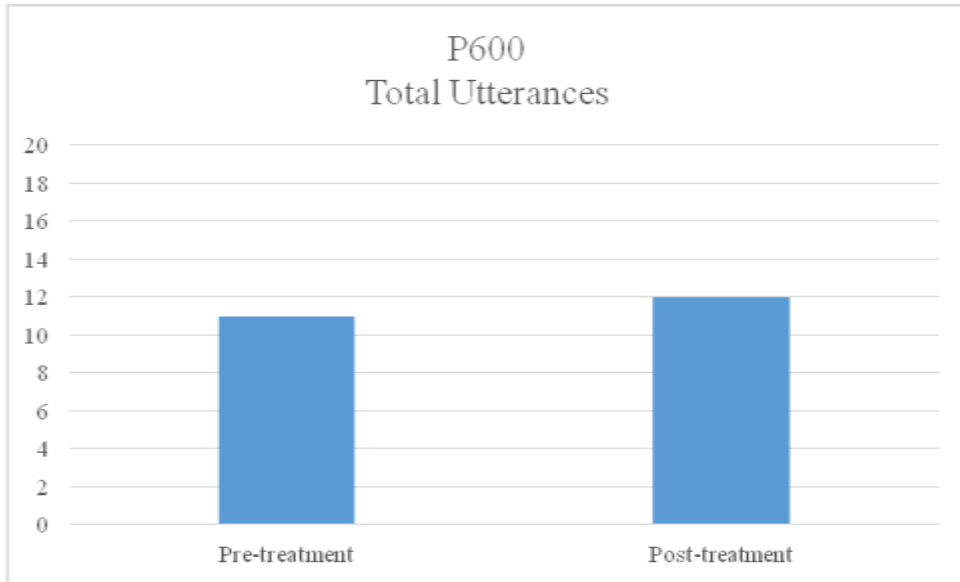


Figure 5.8. Total utterances produced by P600 in written summarization probes.

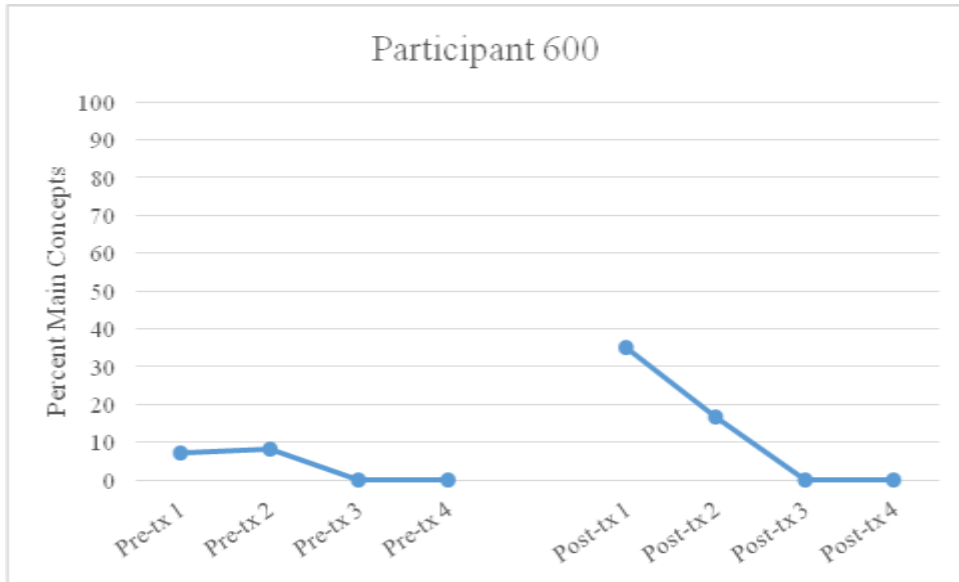


Figure 5.9. P600 percent main concepts conveyed in written summarization probes at pre-treatment and post-treatment.

Pre-tx=pre-treatment; post-tx=post-treatment

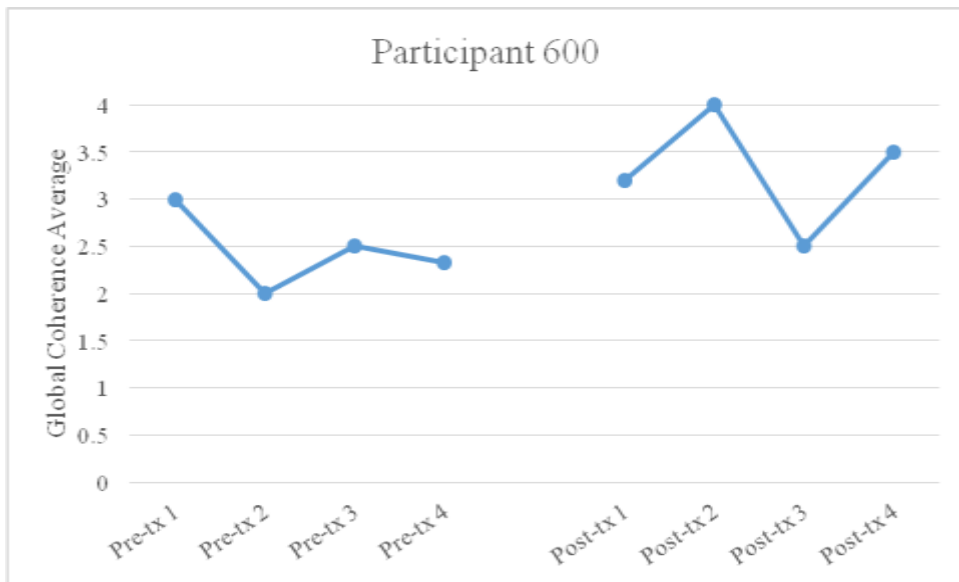


Figure 5.10. P600 global coherence scores on written summarization probes at pre-treatment and post-treatment.

Pre-tx=pre-treatment; post-tx=post-treatment

Control task. P600’s pre-treatment accuracy (averaged over four visits) was 0.06% on nonword writing to dictation (N=34) (Goodman & Caramazza, 1986) and his post-treatment accuracy (averaged over 4 visits) was 0.08%. The effect size from pre- to post-treatment was 0.7025 indicating no effect.

P600: Research Question 2: Effect of ARCS-W on Spoken Discourse

Spoken N&B (1993). P600 produced a higher percentage of relevant words at post-treatment (61.78%) compared to pre-treatment (42.44) and total words decreased (pre-treatment=1039, post-treatment=552). The utterance level measure of %CUs went from 61.80-70.00% from pre- to post-treatment but did not meet our criteria for improvement, and total utterances decreased (pre-treatment=89, post-treatment=50). The percent of grammatically complex utterances did not change (23.94-29.27%).

Of the macrolinguistic measures, global coherence increased from 2.83-3.30, but the percent of main concepts did not increase (54.17-50.0%). See Table 5.4.

Spoken story retell. Percent CIUs increased from 42.97% at pre-treatment to 62.85% at post-treatment and total words decreased (pre-treatment=654, post-treatment=471). Similarly, %CUs also increased (52.08-65.71%), while the total number of utterances decreased (pre-treatment=48, post-treatment=35). The percent of grammatically complex utterances used did not increase (35.90-42.86%).

Both macrolinguistic measures improved with global coherence increasing from 2.76 to 3.27 and percent of main concepts at 62.50% pre-treatment and 81.25% at post-treatment. See Table 5.4.

Table 5.4.
P600 Spoken Discourse Outcomes from Pre- to Post-Treatment

Task	Pre-tx	Post-tx	Pre-to Post Change
Spoken N&B (1993)			
Total Words	1039	552	-487
%Correct Information Units	42.22%	61.78%	+19.56%
CIUs/Min	28.53	30.42	+1.89
Total Utterances	89	50	-39
%Complete Utterances	61.80%	70.00%	+8.20%
%Grammatically Complex	23.94%	29.27%	+5.33%
%Main Concepts	54.17%	50.0%	-4.17%
Global Coherence	2.83	3.29	+0.46
Spoken Story Retell			
Total Words	654	471	-183
%Correct Information Units	42.97%	62.86%	+19.89%
CIUs/Min	25.55	34.82	+9.27
Total Utterances	48	35	-13
%Complete Utterances	52.08%	65.71%	+13.63%
%Grammatically Complex	35.90%	42.86%	+6.96%
%Main Concepts	62.5%	81.25%	+18.75%
Global Coherence	2.76	3.27	+0.51

Note. Pre-tx=pre-treatment, post-tx=post-treatment, maint=maintenance.
 Change of 10 percentage points from pre- to post-treatment are in boldface, except for global coherence in which a change of two standard deviations or more are in boldface (Wright et al., 2014).

P600: Research Question 3: Effect of ARCS-W on Confrontation Naming, Sentence

Production and Functional Communication

P600’s confrontation naming ability did not improve from pre-treatment to post-treatment in the written or spoken modality. His pre-treatment naming of spoken nouns was 93.8% (76/81) and at post-treatment it was 91.36% (74/81). Confrontation naming of written objects was at 72.8% (59/81) at pre-treatment and 76.5% (62/81) at post-treatment. Similarly, spoken action naming did not improve (86%-90%), nor did written action naming (76%-84%).

P600’s sentence production did not improve in the written or spoken modality. Pre-treatment total spoken sentence production accuracy was 81.4% and at post-treatment it was 81.3%. Accuracy of spoken open class words in sentences was 78.8% at pre-and post-treatment.

Total sentence accuracy in the written modality was 78.6% pre-treatment and 79.3% post-treatment with accuracy of open class words at 66.4% pre-treatment and 67.1% at post-treatment.

P600’s communication partner did not rate his functional communication significantly higher at post-treatment based on a Wilcoxon Signed Rank Test (Wilcoxon, 1945) which compared pre- and post-treatment CETI (Lomas, et al., 1978) results ($p=0.4122$). However, she did rate him higher on his ability to understand writing (5.1-8.1 out of 10). P600’s t-score on the ACOM was 57.48 at pre-treatment and 62.15 at post-treatment. This change was not greater than 1 standard deviation (10 points), but was an increase on more than twice the standard error (1.47). See Table 5.5 for results.

Table 5.5.
Participants’ Pre- to Post-Treatment and Maintenance Results for Confrontation Naming, Sentence Production, and Functional Communication

Measure	P100			P600	
	Pre-tx	Post-tx	Maint	Pre-tx	Post-tx
OANB nouns spoken	88.9%	96.3%	98.7%	93.8%	91.4%
OANB nouns written	76.5%	82.7%	91.4%	72.8%	76.5%
OANB verbs spoken	96.0%	90.0%	96.0%	86.0%	90.0%
OANB verbs written	78.0%	82.0%	88.0%	76.0%	84.0%
SPT spoken sentence accuracy	78.3%	77.5%	81.9%	81.4%	81.3%
SPT spoken open class accuracy	80.0%	74.6%	82.5%	78.8%	79.3%
SPT written sentence accuracy	72.9%	77.0%	81.0%	78.6%	79.3%
SPT written open class accuracy	73.8%	71.3%	77.1%	66.4%	67.1%
ACOM	56.57	69.76*	60.6	57.48	62.15
CETI	81.25	80.28	NT	85.59	87.53

Note. OANB=Object and Action Naming Battery (Druks & Masterson, 2000), SPT=Sentence Production Test (Wilshire, Lukkien & Burmester, 2014), ACOM=Aphasia Communication Outcome Measure (Hula, et al., 2015), CETI= Communicative Effectiveness Index (Lomas, et al., 1989).

Change of two standard deviations or greater on the OANB is in boldface.

*indicates a change of one standard deviation or greater on the ACOM.

P600: Research Question 4: Effect of ARCS-W on Cognitive-Linguistic Skills

P600 did not improve on the Cognitive Linguistic Quick Test (Helm-Estabrooks, 2001). His composite score was mild at pre-treatment and post-treatment. See Table 5.6 for detailed results. P600 did improve his ability to maintain global coherence in all discourse tasks across

modality. Maintaining global coherence has been correlated to non-linguistic cognitive skills (Rogalski et al., 2010; Wright et al., 2014) and could be a result of improvement in those skills.

This finding will be interpreted further in the discussion section.

Table 5.6.
Cognitive Linguistic Quick Test (Helm-Estabrooks, 2001) Results for Both Participants at Pre-Treatment, Post-Treatment and Maintenance (P100 Only)

Domain	P100			P600	
	Pre-treatment	Post-treatment	Maintenance	Pre-treatment	Post-treatment
Attention	WNL	WNL	WNL	Mod	Mod
Memory	Mild	Mod	Mild	Mod	Mod
Language	Mild	Mod	Mild	Mild	Mild
Executive Function	WNL	WNL	WNL	WNL	Mild
Visuospatial	WNL	WNL	WNL	Mild	Mild
Composite	WNL	WNL	WNL	Mild	Mild

Note. WNL=within normal limits

Chapter 6: Discussion

The purpose of this research study was to evaluate the effect of ARCS-W in two people with mild aphasia. Additionally, this project represents a phase II study (Robey, 2004) which sought to refine the ARCS-W protocol and replicate the results observed in study 1 (Obermeyer & Edmonds, 2016) with a second cohort of people with mild aphasia. Each participant's response to treatment and the hypothesized mechanisms of improvement are discussed below. Then patterns observed across both participants are discussed, followed by the limitations of this study and the clinical implications.

Before treatment, P100 demonstrated reduced lexical retrieval in isolation and in spoken discourse output, which was effortful. Lexical retrieval in written discourse was more accurate, as indicated by higher percent correct information units, than spoken discourse, but output was sparse, especially in the N&B tasks. See Table 5.2. After treatment, P100 improved his lexical retrieval of objects in speaking and writing. In discourse, P100 demonstrated improvement in his ability to accurately and completely convey main concepts in 4/5 discourse tasks, which indicates that P100 was producing more complete discourse in both written and spoken modalities (Nicholas & Brookshire, 1995). Additionally, P100 increased the percentage of grammatically complex utterances he produced in 3/5 discourse tasks, across modalities. In spoken discourse specifically, P100 produced a higher percentage of relevant words (% correct information units) and complete utterances in spoken story retelling and an increase in grammatically complex utterances and percent of main concepts in both spoken discourse tasks. In written discourse, P100 produced more total words, a higher percentage of grammatically complex utterances (written story retell) and a higher percentage of main concepts.

These findings suggest that the mechanism for P100's improvement was increased lexical

retrieval which resulted in better confrontation naming of objects and better ability to populate complex sentences and convey main concepts in spoken and written discourse modalities. In spoken discourse, P100 continued to demonstrate effortful production characterized by multiple attempts at word retrieval, which adversely impacted %correct information unit and percent complete utterance measures. As a result, those measures only improved in one task (spoken story retelling), while percent main concepts, which are not impacted by word finding behavior, improved in both tasks. In written discourse increased lexical retrieval was evidenced by more complete discourse (percent main concepts), ability to populate more complex sentences (written story retell) and an overall increase in productivity (total words and utterances), while maintaining highly relevant content. See Appendix E for an example of pre- and post-treatment discourse.

At pre-treatment, P600 presented with reduced lexical retrieval and difficulty maintaining topic (global coherence) in spoken and written discourse. Additionally, producing written discourse was extremely effortful and time intensive due to his difficulty spelling. As a result, P600 demonstrated a large discrepancy between his written and spoken discourse production (See table 5.3. and 5.4.). However, his pattern of improvement was similar in both modalities, with the most substantial and consistent increases observed in %Correct Information Units and global coherence (5/5 tasks) across discourse types and modalities.

Measures of word level content and global coherence have been shown to be highly inter-related (Marini & Urgesi, 2012; Wright et al., 2014) in discourse. In spoken discourse, P600 produced a large number of words (see Table 5.4.) and had difficulty maintaining topic (i.e. global coherence) which influenced his percent correct information units, since fewer words were relevant to the topic (i.e. not a CIU; Nicholas & Brookshire, 1993). At post-treatment, P600

had better topic maintenance and as a result more of his words were considered relevant to the topic which increased his percent correct information units. In addition, P600 improved his lexical specificity and produced fewer words at post-treatment (see Table 5.4.) which increased his percent correct information units and the efficiency of his spoken discourse.

P600's performance in written discourse was very different when compared to spoken discourse. He produced very few total words across all writing tasks, demonstrated more difficulty with word retrieval and had considerable difficulty spelling words. Combined, these factors made discourse level writing time consuming and laborious. Similar to spoken discourse, P600 demonstrated the largest improvements in percent correct information units and global coherence in written discourse. However, in written discourse, this change was more heavily influenced by P600's lexical retrieval ability (Wright & Capilouto, 2012). At post-treatment, P600 was more successful retrieving words, produced few neologisms, and maintained topic better. However, written discourse production continued to be extremely effortful for P600 and output remained very sparse which makes interpreting his written treatment outcomes difficult.

The pattern demonstrated in P600's spoken and written discourse suggests that his primary mechanism for improvement was an increased ability to maintain discourse topic with a secondary mechanism of improvement which was lexical retrieval. Although P600's CLQT (Helm-Estabrooks, 2001) (see Table 5.6) score did not improve after treatment, his increase in topic maintenance provides evidence that cognition was an important factor in his improvement, since global coherence has been correlated with processing time, attention and episodic memory (Rogalski et al., 2010; Wright et al., 2014). Additionally, poorer pre-treatment performance and greater post-treatment improvement on the story retelling task, which has a greater cognitive load than N&B tasks, could also be explained by an increase in non-linguistic cognitive skills such as

episodic and working memory which have been correlated to discourse performance (Wright, et al., 2011) and specifically story retelling (Youse & Coelho, 2005). See Appendix F for an example of pre- and post-treatment spoken discourse.

While both participants in this study improved, they did so in different ways, with P100 improving the specific linguistic components of lexical retrieval in isolated and discourse contexts and P600 primarily improving the process of discourse production, specifically topic maintenance. The results of this study provide further evidence that ARCS-W is a treatment option for people with mild aphasia who are interested in improving both their written and spoken discourse. These findings are clinically meaningful since so few treatments are available for people with mild aphasia who want to improve their discourse abilities. While both participants responded differently to treatment, there were some discernable patterns that applied to both.

First, written discourse was scored higher across the majority of outcome measures at pre-treatment than spoken discourse. A similar finding was reported by Obermeyer and Edmonds (2015) when evaluating the written and spoken discourse of healthy adults. This observation is clinically relevant, because the measurements and scales used to assess written discourse were created to evaluate spoken discourse, and in this case, did not appear to capture the participants' functional impairments. Potential reasons written discourse was scored higher could include that participants were less likely to add words they were unsure of, they rarely demonstrated word finding behaviors in writing (e.g. circumlocution, etc.) and they produced less written output than spoken output. One explanation for this could be that participants only write what they are sure of due to the time and effort required to produce written discourse. Other studies have reported that people with aphasia produce fewer words (e.g. Behrns, et al., 2009) in written

discourse, it requires more time to produce (e.g. Ulatowska, et al., 1976) and that writing requires more explicit word selection than speaking (e.g. Behrns, et al., 2009; Gelderen & Oostdam, 2002). Additionally, the participants in this study had mild aphasia, and could monitor their output. As a result, they were often aware when words were not spelled correctly or when the wrong word was produced. In response, if they were unable to produce the correct word, they were more likely not to write anything. In spoken discourse, participants were much more likely to produce comments such as “I am not sure but I think it was _____.” This comparison illuminates some of the modality differences between typing/writing and speaking and the importance of having measures and normative data for writing.

In this study, one measure that appeared to capture change in written discourse was productivity (e.g. total words). When relevant content (e.g. percent correct information units and complete utterances, main concepts) and structure were maintained (e.g. percent complete utterances, global coherence), increased output (e.g. total words, total utterances) appeared to be an indicator of improvement. Measures of productivity (e.g. #CIUs) have been correlated with completeness of main concepts in bilinguals (Rivera & Edmonds, 2014), which could also be the case here. In this study, impaired written discourse often resulted in participants not producing many words. However, after treatment, P100 increased total number of words and % main concepts while maintaining highly relevant content, while P600, who continued to struggle with spelling, did not increase total words.

Another pattern observed from pre- to post-treatment was that both participants made some of their most substantial and consistent gains in the macrolinguistic measures of percent main concepts (P100) and global coherence (P600). This is an especially meaningful finding since macrolinguistic elements of discourse production are not typically targeted in discourse

level treatment even though they are required for all types of discourse production (see Boyle, 2011). Additionally, macrolinguistic measures are often omitted from discourse analysis for people with aphasia even though a variety of studies have reported that people with aphasia can and often do demonstrate impaired macrostructure (see Capilouto, et al., 2006; Christiansen, 1995; Wright, et al., 2014;). This finding provides evidence that macro-linguistic structure should be incorporated into both aphasia treatment and discourse analysis.

Limitations

The observations regarding mechanisms and patterns of improvement observed during this study confirm and expand on those identified in study one (Chapter 2). How these findings can be viewed together to better understand the ARCS-W treatment mechanisms will be discussed in the general discussion section to follow, but first, the limitations of this study should be discussed. First, the summarization probe task proved problematic (like study one). This task required participants to read and summarize a current event news article in writing. They completed this task for four novel articles at pre-treatment and then those four articles were re-administered at post-treatment and maintenance. This protocol represented a shift from study 1 in which novel articles were used at each time point (see Table 4.2). The four pre-treatment probes were repeated to minimize the variability observed in study one. However, in the current study the participants' response to the probe tasks continued to be extremely variable and the task itself was more difficult for this cohort.

The probe articles are controlled for reading level and length, but not for many other lexical factors (e.g. lexical density, lexical diversity, word frequency, etc.). These linguistic factors in addition to each participants' personal knowledge and interest contributed to the variability observed in this task. Additionally, the two participants in this study summarized

approximately 100 word articles during treatment, meaning that the summarization probes were much longer (200-250 words) than their treatment material and therefore, a more cognitively and linguistically taxing task. The difficulty of this task is clear when comparing the results of P100 and P600 across discourse tasks. For example, on multiple probe administrations P600 was unable to produce any complete utterances and the percent of main concepts conveyed was extremely low for both participants (see Figures 5.1-5.10).

Secondly, both participants in this study had very little written output in discourse tasks, especially at pre-treatment, which is consistent with Behrns et al. (2009) who reported that people with aphasia produced fewer total words in written personal narratives than spoken personal narratives. Ulatowska, et al. (1978) reported that producing written discourse took longer for people with aphasia than producing spoken discourse. Additionally, writing took longer for people with aphasia than a group of non-brain damaged controls. Written discourse production also took longer than spoken discourse production in this study, which could have influenced the overall amount participants were willing to produce. The additional time required to produce written discourse could also interact with fatigue and influence total output. The number of words produced has implications for how written data is interpreted. Brookshire and Nicholas (1994) reported that approximately 300-400 words are required for good test-re-test reliability in spoken discourse. That benchmark was not met for either participant at pre-treatment in written discourse. Given the lack of normative data in written discourse, it is difficult to determine to what extent this impacts the current findings, but it should be considered and written data should be interpreted carefully.

The cognitive outcome measures (CLQT; Helm-Estabrooks, 2001) selected for this study were not adequate to assess cognitive function or to evaluate high level cognitive changes that

could result in improvement in discourse. One indication that cognitive linguistic skills did improve with treatment were the changes observed in global coherence for P600. Global coherence has been shown to correlate with attention, processing time, and episodic memory (Rogalski, et al., 2010; Wright, et al., 2014); therefore, improvements in global coherence could be related to those non-linguistic cognitive functions. Moving forward, evaluation of non-linguistic cognitive skills will be a primary outcome measure, which will require assessments of attention, verbal short term memory, working memory, and executive functioning.

Clinical Implications

The findings presented in this study replicate the findings reported in study one with two very different participants with mild aphasia indicating that ARCS-W is a treatment option to improve the written and spoken discourse of people with mild aphasia who can write at the phrase level. One important observation from this study was the treatment response of P600. He improved on a variety of measures in written and spoken discourse largely related to improved topic maintenance. He also demonstrated improvement in his lexical retrieval which resulted in a reduction of neologisms in written discourse. What did not improve was spelling ability, which continued to be time consuming and effortful, especially when he attempted to use the non-lexical route (e.g. when he was unsuccessful retrieving a word from the orthographic output lexicon). This observation is consistent with the theoretical premise of ARCS-W, which requires that participants have relatively strong skills in isolation since specific linguistic processes are not targeted and not likely to improve. This observation also adds to potential writing inclusion criteria which currently only requires participants to be able to write at the phrase level, with no mention of spelling. Although P600 made strong gains in treatment his dysgraphia was an ongoing frustration that made the assessment and treatment tasks difficult. Had P600 received

spelling focused treatment prior to ARCS-W he might have made greater gains. However, it is also possible that the gains he made in ARCS-W will make him more successful with specific spelling remediation, especially considering that non-linguistic cognitive skills appeared to be essential to his improvement.

Another finding of this study was that both participants made more substantial improvements in spoken discourse compared to written discourse. There are many potential reasons for this observation. One is that all the outcome measures used were originally created to evaluate spoken discourse. As such, they may be better suited at measuring spoken discourse while written discourse could require alternative methods. Pre-treatment measures were typically higher in written discourse than spoken discourse (except for percent main concepts). This finding is not a result of extremely high proficiency in writing versus speaking. Instead, it seems to be related to the modality differences exhibited between speaking and writing (as previously discussed). For example, the written modality requires the writer to be more explicit than the spoken modality (Behrns et al., 2009; Van Gelderen & Oostdam, 2002) and often results in less overall output (Behrns, et al., 2009). These factors could substantially impact discourse measures, and as a result, it was more difficult to detect change in measures that were highly accurate at pre-treatment.

Study two included two changes to the treatment protocol reported in study one (i.e., removing key words during summarization and adding homework). It is difficult to determine what effect the changes had on participant outcomes since this cohort presented with very different pre-treatment abilities than the cohort in study one. However, based on the treatment protocol, these changes did appear advantageous and consistent with the desired outcomes. During treatment, removing keywords did not negatively impact the participants' ability to

complete the task, and it appeared to have the desired effect of requiring participants to plan, store and the independently retrieve information.

The purpose of adding a homework task was to encourage generalization to the home environment. Speaking is typically done every day in a variety of contexts and potentially with a variety of partners. However, at pre-treatment, both participants in this study reported that they rarely engaged in writing or typing at home, even though they identified writing/typing as something they wanted to improve. Both participants were compliant with the homework task and P100 often requested additional homework (this request was not granted), which suggests that he found the task meaningful. Therefore, the homework was successful in having participants complete writing tasks independently in the home environment. While the amount of writing completed at home was not measured, P100's wife reported that during treatment he had composed and sent a letter to the motor vehicle administration to dispute a fine. She reported that this was a significant advance, and not a task he would have attempted before treatment. It is reasonable to assume that the written modality allowed P100 to take the time he wished to compose his argument and that the treatment provided him with confidence in his own writing ability.

Summary and Conclusions

In conclusion, the two participants in this study improved their ability to produce untrained written and spoken discourse. These findings replicate the positive results reported in study one (Chapter 2) and provide more preliminary evidence that ARCS-W is a treatment option for people with mild aphasia who are interested in improving their written and spoken discourse. Future studies should evaluate the non-linguistic cognitive skills that are suspected to play a role in discourse production and treatment outcome

Chapter 7: General Discussion

Five participants with mild aphasia have received ARCS-W treatment, all of which demonstrated positive treatment effects in spoken and written discourse measures. These findings are especially encouraging since all outcomes evaluated generalization and no trained stimuli were assessed. The results from these two studies provide preliminary evidence that the top down discourse approach implemented in the ARCS-W treatment was affective at improving both written and spoken discourse in people with mild aphasia. Additionally, these studies have shown that taking a multi-tiered approach to discourse analysis is required to both identify the mechanisms of improvement and to capture that improvement. The five participants who have received ARCS-W can be classified into two presentation types in regard to their pre-treatment impairments and mechanisms for improvement during treatment. Those two presentation types are 1) Impairment in specific linguistic components and 2) Impairment in the discourse production process. Participants in the first presentation type presented with reduced lexical retrieval that was apparent in all language tasks, and potentially more so in complex tasks such as discourse. Participants in the second presentation type demonstrated high level accuracy in isolated language tasks such as confrontation naming and sentence production, but those skills broke down during discourse. These two presentation types will be discussed below, including the participants who fit into each type from both studies.

Presentation type one includes participants who demonstrated reduced lexical retrieval across the linguistic hierarchy. It is important to note that all the participants in the studies presented here had reduced lexical retrieval; however, this group demonstrated more significant problems with lexical retrieval across language tasks (i.e., confrontation naming and discourse) than presentation type two, who had more discourse specific deficits. P2 from study one and

P100 from study two are grouped into this category. These participants' primary pre-treatment deficit was lexical retrieval and it was also their hypothesized mechanism for improvement during treatment. Both participants improved on content related measures across discourse tasks and modalities with P2 improving percent correct information units and percent complete utterances on a variety of discourse tasks and P100 improving percent main concepts in all discourse tasks. Additionally, P2 and P100 were the only participants who demonstrated a clinically significant increase in confrontation naming at post-treatment, indicating better access to/retrieval of lexical items.

Lexical retrieval can improve through a variety of mechanisms. Many treatments designed to improve lexical retrieval attempt to increase activation of specific lexical items via semantic (e.g., Kiran & Thompson, 2003) or phonological methods (e.g., Leonard, Rochon & Laird, 2008) via repeated exposure and treatment of trained items. However, that does not appear to be the case during ARCS-W since each treatment session uses a novel current events article and therefore, stimuli are not repeated. A more likely hypothesis for improved lexical retrieval after ARCS-W is that by emphasizing intentional selection of specific words, the processes that support word selection are improved, which results in increased lexical retrieval in isolation and/or discourse. This is also the perceived mechanism of improvement after Constraint Induced Language Therapy (Pulvermüller, et al., 2001) and ARCS (Rogalski & Edmonds, 2008; Rogalski et al., 2013).

Presentation type two included participants who demonstrated strong linguistic skills in isolated tasks which broke down during discourse indicating that the process of discourse production resulted in disproportionate impairment when compared to isolated linguistic tasks. This presentation type can be broken down further into two differing issues within discourse

production: 1) the cognitive processes required for discourse production are impaired, 2) due to the complex combination of cognitive and linguistic processes required for discourse production, the person with aphasia is unable to successfully allocate their resources or monitor their output. The first situation would indicate that the participant demonstrated an impairment in one or more of the non-linguistic cognitive functions required to produce discourse (e.g., attention, executive function, working memory, verbal short term memory). The second situation implies that because of the complexity of discourse, the participant devotes more resources to specific linguistic tasks at the expense of others. This theory is consistent with a resource allocation theory of attention (McNeil, et al., 1991) and with findings about text writing in people with aphasia (Behrns, et al., 2008).

P3 and P600 (in the spoken modality) appeared to fit into situation one (i.e. impairment in the non-linguistic cognitive skills required for discourse production) of this category. Both participants presented with discourse that was disproportionately impaired compared to their isolated linguistic abilities and mildly impaired scores on the CLQT (Helm-Estabrooks, 2001). Based on anecdotal evidence, P3 required extended time to process information, and had impaired executive functioning that was characterized by difficulty shifting attention. P3 also demonstrated high levels of perseveration, typically at the phrase level, in her discourse. After treatment P3, decreased her processing time for stimuli and decreased her perseverative output in discourse. She also improved relevant words, sentences and main concepts in a variety of discourse types and modalities. Although in-depth cognitive testing was not completed, evidence of these improvements was demonstrated on the CLQT with an improvement from mildly impaired to within normal limits in the executive function domain, improvement on a backward digit span and reduced time required to complete the Ravens Progressive Matrices in the Western

Aphasia Battery Part 2. Additionally, working memory, attention and processing abilities have been correlated with the ability to convey complete story episodes (Youse & Coelho, 2005) and story propositions (Wright, et al., 2001) which P3 improved in a variety of discourse tasks.

P600 is a slightly more complicated case because of the discrepancy between his written and spoken output. Ultimately, he fits best into this category due to the mechanism of his improvement. P600's spoken discourse was characterized by difficulty staying on topic and lexical retrieval deficits. Poor topic maintenance was most obvious in story telling tasks and personal narratives. Written discourse was more impaired and characterized by reduced output, lexical retrieval deficits and dysgraphia. Topic maintenance issues were observed in written discourse, but were not as prevalent as they were in spoken discourse, possibly due to the sparsity of output. After treatment, consistent improvements in global coherence were demonstrated across all discourse tasks. Additionally, in spoken discourse, P600 decreased total number of words while increasing relevant words which suggests that more words were on topic and lexically specific. P600 did not improve on the CLQT, however, his consistent increase in global coherence suggests that his improvement could have been related to non-linguistic cognitive skills such as attention and processing time (Rogalski et al, 2010; Wright et al., 2014). Additionally, he improved more in the story retelling task than the Nicholas and Brookshire (1993) tasks, which could also be a result of increased processing and working memory abilities (Youse & Coelho, 2005).

P1's response to treatment is most consistent with situation two (i.e., breakdown at discourse level due to allocation of resources and self-monitoring). P1 demonstrated excellent lexical retrieval in isolation and relatively high percent correct information units in discourse. After treatment, he improved his ability to use lexically specific words in discourse which

resulted in improved percent complete utterances and percent main concepts in a variety of discourse tasks and across modalities. It was hypothesized that his mechanism of improvement was a result of more efficient self-monitoring. At pre-treatment, P1 made multiple attempts to produce a target and multiple revisions during discourse tasks in speaking and writing. Although he devoted time and resources to achieving the correct target, he demonstrated poor self-monitoring in other areas important for discourse production including use of correct referents, specific word selection and discourse completeness. After treatment, P1 demonstrated much better self-monitoring and could integrate his strong lexical retrieval abilities into more relevant discourse at the microlinguistic (percent complete utterances) and macrolinguistic (percent main concepts) level.

ARCS-W takes a cognitive process approach to improving discourse production in speaking and writing. This is accomplished through constrained summarization in both modalities. Summarization itself is a cognitively and linguistically taxing form of discourse that requires processing, storing, manipulating and retrieving information for discourse production (Ulatowska & Chapman, 1994; Ulatowska, et al., 1999). The use of constraint recruits cognitive and linguistic functions. For example, the constraint of avoiding non-specific words targets intentional selection of lexically precise items. The constraint to stay on topic addresses discourse macro-structure by encouraging participants to be aware of the discourse topic and to maintain that topic in their production. An additional constraint is also added to improve specific impairments for each participant (e.g. look for repeated information, use complete sentences). The constraints implemented in ARCS-W also require that participants implement the meta-linguistic skill of monitoring their language production, which is further emphasized through the addition of writing. Producing written discourse creates a tangible product that can make self-

monitoring easier for participants with aphasia and potentially improve that skill in written and spoken discourse.

ARCS-W requires a complex combination of cognitive and linguistic functions. Attention is recruited for reading and key word identification, intention is required to select lexically specific words, working memory and verbal short term memory are recruited to temporarily store and transform information for summarization, executive function is recruited to plan summaries, discourse production (written and spoken) is required to produce summaries and self-monitoring is needed to implement constraints and then evaluate and revise discourse. The focus on discourse versus the individual language components that make up discourse (e.g. word retrieval, sentence production) allow for an emphasis on macro-structure and the specific cognitive demands of discourse. All five participants who have received ARCS-W improved their micro- and macrolinguistic discourse abilities in the spoken and written modality. These improvements are most likely supported by strengthening the cognitive processes that are required for discourse production. If specific non-linguistic cognitive components such as attention, intention or information processing improve, written and spoken discourse are also likely to improve. Improvement can also be related to an increased ability to self-monitor production, as increased self-monitoring can result in improved consolidation of micro- and macrolinguistic skills within discourse, which appeared to be the case for P1, who demonstrated the most widespread and consistent improvement of all participants who have received ARCS-W.

Limitations

One of the primary limitations for both studies was the lack of assessment of non-linguistic cognitive skills. The absence of this information makes it difficult to pinpoint some of the hypothesized mechanisms of improvement. Moving forward, cognitive assessment will

compose a large part of the outcome measures for this treatment.

Another limitation is the difference in outcome measures between study one and two, which is not uncommon in phase I and phase II studies (Robey, 2004), but makes comparison of the two studies more difficult. Study two had a more complete approach to discourse analysis including percent correct information units, percent complete utterances, percent grammatically complex utterances, percent main concepts, and global coherence, which provided more insight into each participants' discourse abilities, while study one only evaluated percent correct information units, percent complete utterances and percent main concepts. This was especially limiting in regard to global coherence. In study two, P600 made substantial gains in global coherence. It is also likely that participants in study one would have made improvements in global coherence, and evaluating it could have further confirmed the hypothesized mechanism of improvement for P3. In the future, the additional analyses completed in study two can be completed for the discourse samples of the participants in study one to provide more insight and make comparisons across studies.

The small number of participants in treatment studies is always a limitation because results cannot be widely generalized. However, it is a necessary step to developing preliminary evidence for a newly adapted treatment before larger group studies should be attempted. These two studies have accomplished many of the goals of phase I and phase II studies (Robey, 2004). Study one provided positive and interpretable results that were replicated in study two. In the second study, the treatment protocol and discourse outcome measures were refined and implemented successfully with two additional participants with mild aphasia. Study two also provided more thorough information about participant eligibility criteria. Limitations in the current outcome measures include the cognitive assessment (already discussed) and the probe

task, which continues to be too variable to provide easily interpretable results. These issues will have to be addressed before ARCS-W can progress to a phase III study, at which point treatment efficacy can be established (Robey, 2004).

Clinical Implications

Five people with mild aphasia have improved their ability to produce written and spoken discourse as a result of ARCS-W. Based on their responses to treatment, a few statements can be made about who is the most appropriate for ARCS-W treatment. First, ARCS-W is only appropriate for people with mild aphasia. These criteria are essential to insuring that participants can complete the treatment tasks which require spoken and written discourse and high level meta-linguistic evaluation of discourse production. It is likely that this process would be extremely frustrating for participants who are more than mildly impaired. Additionally, the entire language profile should be considered before the diagnosis of mild-impairment is made which includes spelling abilities. ARCS-W is not a dysgraphia treatment and does not seek to rehabilitate specific spelling issues.

Discourse analysis is an important outcome measure for treatment, especially discourse level treatment. However, discourse analysis requires a shift in approach from what is typical in treatment studies. When discourse is evaluated, a multi-tiered approach that evaluates micro and macrolinguistic skills should be adopted (see, Altman, et al., 2012; Marini et al., 2011, Wright & Capilouto, 2012). Additionally, improvement in each discourse measure should not be expected, instead, the measures should be used to identify the discourse level impairments that each participant demonstrates and then evaluate the effect of treatment. Doing this is not always simple since discourse is such an integrated process (Andreetta & Marini, 2015; Wright & Capilouto, 2012). For example, P2 and P100 both improved their lexical retrieval ability. For P2,

this resulted in improvement in percent correct information units and percent complete utterances. For P100, his improved lexical retrieval was demonstrated by an increase in percent main concepts due to continued effortful production that often included fillers and multiple attempts at production. While a variety of measures can and often do improve, a multi-tiered discourse approach can assist in the identification of specific patterns of impairment and improvement.

Summary and Conclusions

Writing/typing is a critical component to modern life, and can make communication more accessible for people with aphasia. However, without evidenced-based writing/typing treatment people with aphasia cannot benefit from the increased accessibility that technology provides (Dietz, et al., 2011). ARCS-W fills a gap in clinical research for people with mild aphasia who are interested in improving their text level written output. The five participants presented here improved their spoken and written discourse after receiving ARCS-W treatment. These findings are promising and provide rationale for continued research to evaluate the efficacy of ARCS-W, especially in relation to potential cognitive outcome measures that could improve after treatment and/or be important predictors of treatment outcomes. Not only did participants improve in written discourse, which is the primary focus of treatment, they also demonstrated strong, often stronger (study two), improvements in spoken discourse. These findings support the multi-modality top-down approach of ARCS-W, which emphasizes the process of discourse production.

Future Directions

The results presented here provide strong rationale for the continued exploration of the ARCS-W treatment. Future studies should evaluate the non-linguistic cognitive variables that are

important for discourse production and those that are hypothesized to be important during treatment. Additionally, the lack of normative data in the written and typed modality should be addressed so that treatment effects can be measured more reliably. Accomplishing these goals could provide a platform for ARCS-W to be administered to different clinical populations (e.g., people with traumatic brain injury) and through different service delivery models (e.g., group treatment).

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Appendix A

Table A1.

ARCS-W Treatment Steps for Study 1

<u>Treatment step</u>	<u>Participant Action</u>	<u>Clinician action</u>
Step 1	n/a	Clinician reads entire article aloud
Step 2	Participant reads 1-3 sentence segment twice, to themselves, for comprehension	n/a
Step 3	Participant identifies key words in the segment and writes them down	Clinician writes down key words from the segment
Step 4	Participant and Clinician compare key words, discuss what's most important and finalize list of key words.	
Step 5	Participant produces a verbal summary of the segment they read with the assistance of their key word list while following prescribed constraints (e.g. no nonspecific words, stay on topic)	Clinician provides feedback regarding if constraints were followed and if important information was included (key words).
Step 6	Participant summarizes segment in writing and then read it to the clinician and check for errors	Clinician provides feedback regarding if constraints were followed and if important information was included (key words).
Repeat until entire article is summarized		
Step 7	Participant re-reads/listens to the entire article	
Step 8	Participant produces summary of the entire article verbally	Clinician provides general feedback about completeness of the summary.
Step 9	Participant writes summary of the entire article	Clinician provides feedback on completeness.
Step 10	Participant rates the completeness of their written summary on a scale of 1-5 (e.g. 1= not complete at all, 3=somewhat complete and 5= very complete)	

Appendix B

Microlinguistic Coding Examples

Example of CIU coding from P600 N&B (1993) Argument sequence written description
 Words in red are CIUs and words. Words in black are words and not CIUs.

A COUPLE ARUGE[EW:argue] AT HOME.
 THE WIFE PACK HER LUGGAT[EW:luggage] AND LEFT.
 THE MAN IS AT HOME SULKING.
 THE WIFE CAME BACK.
 AND THE COUPLE MAID[EW:made] UP.
 THE CAR WAS HIT BY THE WIFE.

Table B1.

Complete Utterance Coding Example from P100 Baseline Written Cookie Theft Picture Description

Utterance	Subject + Verb +(Object)	Relevant	Complete Utterance
The mom is doing dishes[EW:dishes].	Yes	Yes	Yes
And the water offloile[EW] in to the floor.	No	No	No
The kids are trying to get some cookies.	Yes	Yes	Yes
The son is fli[EW:fly] off the stool.	Yes	No	No

Table B2.

Example of Grammatical Complexity Rating Based on Altman, Goral and Levy (2012)

P100 Post treatment written Birthday picture description utterance	Complexity Score	Rationale
Jan and her son Joe had a birthday party with four gust[EW:guests].	2	Simple and complete sentence
The dog eat a piece off the cake	2	Simple and Complete sentence
Joe cried while Jan was mad at her dog	5	Sentence with complete subordinate structure

Appendix C

Macrolinguistic Scoring Examples

Table C1.

Main Concepts Scoring Example

P600 N&B (1993) Argument sequenceWritten Utterance produced	Main Concept Score	Main Concept identified by Capilouto, Wright, and Wagovich (2005)
COUPLE ARUGE[EW:argue] AT HOME	Complete	The husband and wife are yelling at each other/get in a fight.
THE WIFE PACK HER LUGGAT[EW:luggage] AND LEFT	Complete	She packs her bag and leaves/heads for the door.
HE MAN IS AT HOME SULKING	Complete	The husband/man is sad/distraught/upset
THE WIFE CAME BACK	Incomplete	The wife comes back in the house/opens the front door/peeks in the door.

Table C2.

Global Coherence Scoring Examples

P100 post treatment N&B cookie theft written utterances	Global coherence score	Rationale
The boy is reaching for cookies	4	Directly related to a main detail of the picture
He x[ST] is triping[EW:tipping] on the stool	3	Related to a main detail but inference is required
The woman is washing the dishes	4	Directly related to a main detail of the picture
The water is running over the sink	4	Directly related to a main detail of the picture
The grass is growing	2	Related to an unimportant detail in the picture
The window is open	2	Related to an unimportant detail in the picture

Appendix D

Homework Instructions for Study 2

Homework instructions:

1.) Read the entire article twice for comprehension with the intent to summarize

2.) Underline the most important key words/phrases in the article.

3.) While looking at the article, plan what you want to include in your written summary.

3.) Write a summary of the article using your constraints:

1.) Don't use non specific words

2.) Stay on topic

3.) Use complete sentences

Try your best to write the summary without looking back at the article (you can look back if you have to though).

4.) Once the summary is complete read it through and ask yourself the following questions:

1.) Was I as specific as possible?

2.) Did I stay on topic?

3.) Did I use complete sentences?

4.) Did I include the most important information?

5.) Make sure you bring the article and the summary to your next treatment session.

Appendix E

Examples of pre-treatment and post-treatment written discourse for P100

P100 Pre-treatment description of N&B (1993) Birthday scene.

The mom is smar d[ST] at her dog when he jump on the table and bite some ol[ST] of her cake.
The light[EW] guy is crams[EW].
The guests (2) is arrived the house.
The guy is carrying a presents wl[ST] with his mother.
The girl is carr[ST] carrying a present wh[ST] with his mom, who has on a stripe xxx[blank].
The x[ST] furniture is open an[ST] while the mom swipe the dog.

P100 Post-treatment description of N&B (1993) Birthday scene.

The dog is hind[EW:hide] under the soaf[EW:sofa].
The dog x[ST] has a trail of pawn[EW:paws] from the cake than[EW:that] he has bitten.
The mother has a broom of[ST] at the dog.
The child is crying.
the first visitor has a child when[EW:with] her.
She has a dress.
The boy has a guist[EW:gift] for[ST] from then[EW:them].
The girl has a bigger box and a flower.
The young woman, who is writing[EW] then, has a top and a shaded bottom.
There are[ST] is one picture.
There is one window, when[EW:with] a tree and clouds.
There is one sofa, a lamp, chair and a cocktail.
There is 4 candles.
The door is open to allow then[EW:them] to come in.

Appendix F

Examples of Pre-Treatment and Post-Treatment Spoken Discourse for P600

P600 Pre-treatment spoken story retell

okay it's it's a it is a story about (um) a man with his son.
they (w*) they just went to finish almost no they actually did some (:03) cleaning the (s* s* s* sa*) in the
sideway of (uh :02) by their their house cause it was because it had some it was some had some snow
they had to shovel some snow .
so they got home.
(um) the the dad wanted to get something to (t*) to eat.
so the son (:02 um) went into the kitchen to give his dad some (f* uh) some food and also some
cookies.
; :02
while (um) the son was busy (:02) doing his homework.
and he was getting ready for (um) his (uh) his his (um) home homework.
he was a little annoyed that his his son >
; :03
because his (ma*) his his dad was always asking for everything.
so he decided to tell him please help me a little bit because I'm doing something really (uh)
hard with my homework.
; :02
so the (s*) son told him where he can find water.
but but it's it seems like it's a good story about (um) the son and his and his son the dad no I'm sorry
it's it's about a story about a dad (:02) and son who loves to help his his (um :02) his (um) dad.
probably has maybe he's (um) maybe he's a stroke victim.
that's not even the right word these days right when you say (um) he's he might be a (vic* um) victim.
well anyway he had a stroke probably of some sort that he can't >
that's what it seems like cause I mean he didn't even know how to where do I where do I go to
(uh) get water in their house.
So it's kinda weird but but XXX {laugh} >

P600 Post-treatment spoken story retell

okay (um :03) this is a story about (:02 um) a a man that has (uh) a son.
(uh) the name of the man was (um) >
what's his name?
Sir Adams just finish finishing her no his (um) driveway , no actually {laughs} he just finish doing (um)
cleaning his driveway through (um uh) from the snow {clearthroat} while his (uh) his son was getting
ready with (um :02) some work on (sca*) school.
so Mr Adams told (:02 um) Ben his his son to make a sandwich which was a cheese sandwich
and (um) brought it to to Mr Adams.
; :03
and also wanted some (um) cookies Mrs Adams Mr Adams that (um) got from the neighbor.
after he (:02) after Dr (uh) Mr Adams ate he told his son Ben to please get him some I think he
needed some some water.
but Ben was busy getting his finals from from a (uh) working on his (s*) school (uh) from from
work I mean from high school .
so Ben asked his dad Mr Adams if he could (:02) try to do his own (:02) cooking or making
his own meals once in a while because he's he's also busy.
; :04
and it ended up the story was Mr Adams didn't know even where their water was {laughs}.