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Effects of Semantic Feature Analysis+Multimodal Communication Program for Word Retrieval and Switching Behavior in Primary Progressive Aphasia

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EFFECTS OF SEMANTIC FEATURE ANALYSIS+MULTIMODAL COMMUNICATION PROGRAM FOR WORD RETRIEVAL AND SWITCHING BEHAVIOR IN PRIMARY PROGRESSIVE APHASIA

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By

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ABSTRACT

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Thesis supervised by Sarah E. Wallace, Ph.D.

Primary progressive aphasia (PPA) is a neurodegenerative condition characterized by language and cognitive decline. Word retrieval deficits are the most common PPA symptom, and contribute to impaired verbal expression. Intense semantic interventions show promise for improving word retrieval in people with PPA. Additionally, people with PPA may learn to use alternative communication modalities when they are unable to retrieve a word. However, executive function impairments can cause people to struggle to switch among modalities to repair communication breakdowns. This study examined the effects of a combined semantic feature analysis and multimodal communication program (SFA+MCP) on word retrieval accuracy and switching among modalities in a person with PPA. Changes in word retrieval accuracy and switching were minimal. However, the listeners' identification of the participant's communication attempts was more accurate following treatment, suggesting increased overall communicative effectiveness. These results have implications for the design of future PPA intervention studies.

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CHAPTER I

Introduction

Word Retrieval Deficits in Aphasia

Primary progressive aphasia (PPA) is a neurodegenerative condition characterized by gradual decline in language and eventually, cognitive functions. Initially, people with PPA present with characteristics similar to people with stroke or brain injury-induced aphasia; however, PPA differs in that language abilities decline over time and cognitive impairments may become present after the first 2 years of onset (King, Alarcon, & Rogers, 2007). Cognitive deficits experienced by people with PPA are similar to those found in people with dementia and include impairments in executive functions, non-verbal problem solving, verbal memory, and short-term memory (King et al., 2007). Although some cognitive changes may be evident in early stages, progressive language deficits are the main symptom of PPA. Language impairments associated with PPA include spelling difficulties, abnormal speech patterns, and word retrieval deficits (Beukelman & Mirenda, 2013; Mesulam, Wieneke, Thompson, Rogalski, & Weintraub, 2012). Similar to aphasia resulting from stroke or brain injury, word retrieval deficits are the most common symptom of PPA (Mesulam et al., 2012).

Word retrieval is a complex process (Dell, Lawler, Harris, & Gordon, 2004). To retrieve a word, a visual stimulus is translated into a conceptual representation, the name of the stimulus is retrieved, and the name is articulated (Dell et al., 2004). Dell and colleagues (2004) hypothesized a model of lexical retrieval, which described retrieval of the name of a stimulus as a two-step process. The first step of the process is lemma access. Lemma access is the connection of a concept to a semantic representation of a word (i.e., the lemma). Lemma access begins when semantic features of a stimulus are activated, and continues until the most active unit, such as a noun, is selected. The second step of the process is phonological access. Phonological access is the connection of the lemma to the phonological form of the word, resulting in verbal expression of the word. Phonological access begins when the target word is activated, and continues to activate the phonemes of the word to produce verbal expression of the word.

Word retrieval deficits occur within either, or both, step of lexical retrieval. Deficits within lemma access lead to activation of non-target words, whereas deficits within phonological access lead to activation of non-target phonemes (Dell et al., 2004). Therefore, deficits within either, or both, step of lexical retrieval lead to verbal communication difficulties. As a result, intervention to address word retrieval deficits is warranted.

Semantic Intervention for PPA

Semantic feature treatments have been examined extensively in people with chronic aphasia (e.g., Boyle, 2004; Kiran & Bassetto, 2008). These treatments are based on the spreading activation theory (Collins & Loftus, 1975), in which the activation of a specific feature results in the automatic activation of semantically related concepts. Outcomes of semantic feature interventions implemented in people with stroke or brain injury-induced aphasia included variable improvements in word retrieval during confrontation naming tasks and in connected speech, for both trained and untrained words (Boyle, 2004; Boyle & Coelho, 1995; Coelho, McHugh, & Boyle, 2000; Masaro & Tompkins, 1992).

Recently, researchers have demonstrated improvements in word retrieval for people with PPA following semantic interventions. McNeil, Small, Masterson, and Fossett (1995) examined a semantic and phonological cueing hierarchy for training predicate adjectives; lexical retrieval improvements were noted for trained words, as well as generalization to untrained words and word classes. Henry, Beeson, and Rapscak (2008) implemented an intensive semantic feature treatment for people with PPA. Results indicated significant treatment effects for word retrieval of trained semantic categories. Beeson and colleagues (2011) explored an intensive 2-week semantically-based treatment supplemented by completion of daily, 1-hour semantically-based homework tasks focused on reviewing items within a target category. This treatment approach resulted in improved retrieval of words within trained and untrained categories for a person with PPA. Follow-up measures completed at 6-months post-intervention revealed sustained treatment effects.

While findings support the value of semantically-based interventions for people with PPA to improve word retrieval, clinicians should also consider the neurodegenerative nature of PPA as they design appropriate treatment programs (Thompson & Johnson, 2005). Specifically, clinicians may implement treatments with the intent to restore linguistic abilities, but should also consider instruction in the use of compensatory strategies for word finding should retrieval errors persist. For example, in addition to providing a semantically-based intervention, instruction in the use of alternative modalities may potentially improve overall communicative effectiveness.

Alternative Communication Modalities

Alternative communication modalities include writing, drawing, gesturing, using low-technology devices (i.e., communication notebooks), and using high technology devices (i.e., speech generating devices). These alternative communication modalities are traditionally used to help people with complex communication needs manage communication breakdowns (Beukelman & Mirenda, 2013). Many reports in the literature highlight the use of multimodal communication systems by people with stroke-induced aphasia. Multimodal communication systems include the use of multiple alternative communication modalities to allow the person with aphasia to use different strategies for various situations and communication partners (Hux, Weissling, & Wallace, 2008). For example, Dietz, McKelvey, Schmerbaugh, Weissling, and Hux (2011**)** implemented a system of alternative communication modalities including drawing, writing, using a low-technology communication book, and using a high-technology device to increase the communicative effectiveness of a person with severe chronic aphasia**.** Following intervention, the use of the alternative communication systems resulted in successful interactions with familiar and unfamiliar communication partners. Although communication breakdowns persisted, the person with aphasia had developed multiple approaches to resolve breakdowns. Ideally, multimodal communication systems allow people with aphasia to resolve breakdowns and to meet their communication needs in a variety of ways.

Less is known about multimodal communication systems used by people with PPA, but given their shared characteristics, it is likely that this population would derive similar benefits from a system of compensatory strategies. That is, people with PPA are candidates for using alternative communication modalities because their language impairments result in communication breakdowns, which lead to unmet communication needs (Beukelman & Mirenda, 2013). Rogers and Alarcon (1998) and Thompson and Johnson (2005) recommended the use of alternative communication modalities to increase the communicative effectiveness in people with PPA. For example, Rogers and Alarcon (1998) suggested providing a variety of communication modalities to increase communicative effectiveness. Thompson and Johnson (2005) recommended intervention to target both impaired language and the use of alternative communication strategies. Specifically, the authors indicated that language interventions implemented for people with aphasia resulting from stroke may be appropriate for people with PPA, and that instruction in multimodal communication strategies should be implemented in anticipation of future language decline. Thompson and Johnson (2005) suggested providing these interventions during the early stages of PPA because people with PPA may have difficulty learning these strategies during the late stages. Riesthal (2011) provided an example of a combined intervention program for PPA. The author implemented a successful intervention program for a person with PPA that included family and patient education, instruction in the use of a picture based-AAC book, and a behavioral treatment to target a specific language impairment.

Given the importance of multimodal communication strategies for people with aphasia and PPA, examination of the best methods to instruct people with aphasia to use alternative modalities is warranted. Purdy, Duffy, and Coelho (1994) examined a multimodal intervention for people with stroke-induced aphasia, which included the use of verbal communication, gestures, and a communication board. The alternative communication modalities were taught individually with the overall purpose of teaching the people with aphasia to use multiple modalities to communicate and resolve communication breakdowns. Although participants learned to produce the communication modalities, they were unable to switch among modalities to repair communication breakdowns. For example, although the participants had the least success with the verbal modality during training, this modality was the most frequently used when a communication breakdown occurred. Purdy and colleagues (1994) hypothesized that the inability to switch among modalities was due to executive function impairments in people with aphasia.

Executive Function Impairments

A number of studies have examined the executive function impairments in people with aphasia (e.g., Glosser & Goodglass, 1990; Frankel, Penn, & Ormond-Brown, 2007; Purdy, 1994;

Helm-Estabrooks, 2002). Purdy (2002) examined executive function abilities in people with aphasia through non-verbal tasks, which measured two areas of executive functions, goal directed-planning and cognitive flexibility. Results indicated that decreased executive function performance was primarily due to cognitive flexibility deficits. Cognitive flexibility includes the ability to consider alternative responses, modify behavior based upon situational changes, and generate multiple ideas (Eslinger & Grattan, 1993).

Cognitive flexibility is one of the specific areas of cognition that declines as PPA progresses (Zakzanis, 1999). As previously noted, PPA is characterized by gradual cognitive decline such following 2 years with primary changes related to language functions. Therefore, although executive function impairments may not be evident in early stages, as PPA progresses people may experience changes in cognitive flexibility (Léger & Johnson, 2007). These cognitive flexibility impairments may result in changes in functional daily activities including those that require communication skills.

Communicative effectiveness in people with aphasia is limited by impairments in cognitive flexibility. One limitation relates to a reduced ability to switch among multiple communication modalities to resolve breakdowns. As examined by Purdy and colleagues (1994), deficits in the participants' cognitive flexibility resulted in the inability to switch among modalities when a communication breakdown occurred. Based on their communication and cognitive impairments, it is likely that the communicative effectiveness of people with PPA is also affected by deficits in cognitive flexibility. Reduced communicative effectiveness in people with PPA may be caused by impairments in switching behavior, similar to those observed in people with stroke or brain injury-induced aphasia.

Switching Behavior in Aphasia

Purdy and Koch (2006) examined cognitive flexibility in relation to communication modality use in people with aphasia. The researchers developed a modified scoring system for the *Communicative Activities of Daily Living-2* (*CADL-2*) (Holland, Frattali, & Fromm, 1999), with the purpose of capturing modality switching. Modified scoring of the *CADL-2* was obtained by recording all response modalities, both verbal and non-verbal, produced during the assessment. If an initial communication attempt was not successful, this became an opportunity for the person to switch to a second modality. If the person switched to a second modality this was considered a successful switch. The number of successful switches out of the number of opportunities to switch (unsuccessful initial attempts) was represented as a percentage, referred to as the communicative flexibility score. The researchers found that the *Wisconsin Card Sorting Test (WCST)* (Grant & Berg, 2003) score significantly correlated with the *CADL-2* communicative flexibility score. Although the *WCST* is a standard test of cognitive flexibility, the communicative flexibility score of the *CADL-2* provided a cognitive flexibility measure in a communicative context, and provided information regarding the relationship between cognitive flexibility and communicative switching behavior.

To further examine *CADL-2* scores, Purdy and Koch (2006) compared the participants' communicative flexibility scores with performance on a referential communication task (RCT). Results indicated that the use of switching during the *CADL-2* was correlated with the use of switching during the RCT. Therefore, the communicative flexibility score may also be used to predict the ability to switch modalities during a communication task.

Chiou and Kennedy (2009) compared switching ability of people with and without aphasia during tasks that required minimal-language processing. Results determined that people with aphasia demonstrated an impaired ability to switch between the rules of the task compared to people without aphasia. Similar to Purdy and colleagues (1994), the researchers concluded that switching ability effects communicative effectiveness. Therefore, to increase communicative effectiveness, interventions to address switching behavior are needed.

Modality Switching Intervention

Purdy and VanDyke (2011) examined the effects of a multimodal communication training (MCT) program in two people with chronic stroke-induced aphasia. MCT aimed to instruct the use of multiple modalities (i.e., speaking, writing, gesturing, and pointing to a communication board) simultaneously for one concept, prior to instruction of modalities for a second concept. This integrated teaching of multiple alternative modalities was intended to create greater automaticity among verbal and non-verbal modalities, therefore resulting in increased switching among the modalities to resolve communication breakdowns. In this way, the alternative modality instruction would result in circumventing of step two (phonological access) deficits in the two-step process of lexical retrieval (described above). Results indicated that simultaneous teaching of multiple modalities improved one participant's ability to switch among modalities during a RCT. However, the participant with prominent semantic impairments required an additional semantic intervention following MCT before switching behavior improved. Purdy and VanDyke (2011) hypothesized that for some people with aphasia and semantic impairments, this additional semantic intervention was needed to remediate deficits in step one (lexical access) of the two-step model of lexical retrieval.

Carr and Wallace (2013) examined the effects of a semantic plus multimodal communication program (S+MCP) for switching behavior in a person with severe aphasia and semantic impairments. The semantic feature intervention required the participant to sort semantic features for each word prior to completing multimodal instruction for that word. The goal of this treatment was to simultaneously address deficits in both steps of lexical retrieval to facilitate improved modality switching. Although the participant's switching behavior improved significantly, the effect of treatment was delayed until after 12 treatment sessions. The delay suggests that investigations of alternative approaches to this intervention may be warranted.

Wallace, Purdy, and Skidmore (*in press*) investigated a multimodal communication program (MCP) for aphasia implemented during acute stroke rehabilitation. This treatment was provided intensely at 6 days per week for 2 to 3 weeks; however intervention sessions were shortened (approximately 30 minutes each) to minimize patient fatigue. Similar to MCT, MCP instructed the use of multiple verbal and non-verbal modalities simultaneously for one concept, prior to instruction of modalities for a subsequent concept. Descriptions of the participants' performance during modality production tasks indicated that implementation of MCP increased the participants' accuracy of production of various communication modalities. However, only one participant's switching behavior increased following MCP. Similar to Purdy and VanDyke (2011), the participant with aphasia and semantic deficits did not demonstrate improvements in switching among the communication modalities. However, this participant did increase his use of alternative modality productions, particularly gesturing and drawing, following intervention indicating some benefit to his communicative effectiveness.

Communicative Effectiveness

To evaluate communicative effectiveness in adults with aphasia, researchers examined the accuracy with which six observers interpreted patient-generated self-cues (e.g., gesturing, writing, and providing verbal functional descriptions) (Tompkins, Scharp, & Marshall, 2006). Observers viewed video recordings of 10 people with aphasia producing target words in 107 utterances. The purpose of this study was to compare two groups of observers, only one of which received instruction in the communication patterns of people with aphasia. However, most relevant to the current study, observers were able to predict the intended target words with 56% accuracy (instruction group) and 31% accuracy (non-instruction group). That is, regardless of the accuracy of the patients' word retrieval, when observers were provided with verbal functional descriptions, gestures, and combined self-cues (gesturing while providing verbal functional descriptions) they could often determine the patients' intended meaning. These results indicate that observers' identification accuracy could potentially be a valuable measure of communicative effectiveness, when combined with other measures such as word retrieval accuracy.

Applications to PPA

Although multimodal instruction has not been examined in people with PPA, an instructional approach that incorporates a semantic and multimodal communication intervention is appropriate for at least three reasons. First, semantic interventions when delivered at increased intensity have been shown to improve spoken expression of people with PPA (Beeson et al., 2011). Improvements or maintenance in spoken expression are significant for people with PPA particularly in the early stages of this condition. Second, because of the progressive nature of PPA, people will likely require the use of alternative communication modalities as their language abilities decline. In early stages, non-verbal modalities may support occasional word finding problems; while in later stages, these modalities may become a primary mode of communication. An instructional program, which also addresses potential executive function or cognitive impairments, may best help people repair communication breakdowns. There is preliminary evidence to suggest that multimodal interventions can also be delivered with increased intensity

(Wallace et al., *in press*; Attard, Rose, & Lanyon, 2013). Third, early instruction in the use of alternative communication modalities for people with progressive conditions allows for learning to occur when cognitive abilities are highest and most supportive of new learning (Beukelman & Mirenda, 2013). Additionally, early instruction provides multiple opportunities to practice desired behaviors resulting in greater acquisition of these skills (Beukelman & Mirenda, 2013).

Instruction with a semantic plus multimodal communication instruction (SFA+MCP) may result in improved communicative effectiveness for people with PPA. Investigation of this hypothesis was the primary aim of this study. Specifically, the researcher hypothesized that the semantic component of the intervention was needed to strengthen activation within the semantic network, resulting in improved word retrieval accuracy. Due to the neurodegenerative nature of PPA, MCP was necessary to increase alternative modality production and switching among multiple modalities to repair communication breakdowns. Finally, a naïve listener task served as a measure of overall communicative effectiveness.

Purpose and Research Questions

The purpose of this study was to examine the effects of a combined semantic feature analysis and multimodal communication program (SFA+MCP) on word retrieval and the ability to switch among modalities in a person with PPA. Specifically, this study aimed to answer the following questions:

1. Does implementation of SFA+MCP affect the accuracy of a person with PPA to retrieve words during a confrontation naming task?
2. Does implementation of SFA+MCP affect the ability of a person with PPA to switch among modalities when an initial communication attempt fails during a referential communication task?

3. Does implementation of SFA+MCP affect the communicative flexibility score of a person with PPA during administration of the *CADL-2*?
4. Do naïve listeners identify the participant's communication attempts with greater accuracy following SFA+MCP?

CHAPTER II

Methods

Experimental Design

An experimental, single-participant, multiple baselines across stimuli (word lists) design was utilized. SFA+MCP was completed across two treatment phases (treatment phase one and treatment phase two), with four treatment sessions within each phase. During treatment phase one, word list one was treated; word list two and word list three were not treated. During treatment phase two, word list two was treated; word list one and word list three were not treated. To reduce the possibility of participant fatigue, a 1-week break was given between treatment phase one and treatment phase two.

Word lists one and two were probed at the beginning of each intervention session within treatment phase one and treatment phase two. Word list three was probed at the beginning of every-other intervention session within both phases. All three word lists were probed during baseline and post-intervention sessions. The word lists were probed during baseline, intervention, and post-intervention sessions to examine word retrieval accuracy during a confrontation naming task (CNT), and switching behavior during a referential communication task (RCT). Following post-intervention sessions, a listener task was implemented to investigate listeners' accuracy of identifying the participant's communication attempts during the RCT.

Participant

Following approval of the research protocol from the Duquesne University Institutional Review Board, participant recruitment began. Recruitment of potential participants occurred through distribution of a flyer in the Duquesne University Speech-Language and Hearing Clinic (Appendix 1). One person with PPA was recruited for participation.

An 81 year-old, college educated female participated in the study. Her husband noted that her word-retrieval difficulty began approximately 2 to 3 years prior to initiation of the study. The participant's neurologist conducted assessments, and an aphasia variant of dementia, probable PPA, was suggested. The participant did not have a history of speech, language, or cognitive impairments before the onset of PPA. The participant was right-handed prior to the diagnosis of PPA, and used her right hand to write and draw during the study. She lived at home with her husband, and was ambulatory. The participant spoke American English as her first and primary language, and did not have self-reported unaided hearing or vision impairments (she wore reading glasses). She was not enrolled in speech and language therapy prior to, or during the study. Her demographic information is provided in Table 1.

Table 1. Participant's demographic information.

Age	81 Years Old
Gender	Female
Education	Ph.D.
Occupation	Retired (Previously a Social Worker)
Residential Status	Lives with Spouse
Native Language	American English
Dominant Hand	Right
Ambulatory Status	Within Normal Limits

As criteria for inclusion in the study, the *Western Aphasia Battery-Revised* (*WAB-R*) Auditory Word Recognition Subtest and an experimental confrontation naming task were completed to determine if the participant's naming and comprehension abilities were sufficient to complete the study. The participant received a score of 57/60 (95%) on the Auditory Word Recognition Subtest, and a score of 8/30 (26.67%) on the experimental confrontation naming task. Based on previous studies (e.g., Boyle, 2004), a criterion ceiling of 80% (24/30) on the experimental confrontation naming task was established to insure the participant could derive benefit from the modified SFA intervention. The participant's baseline formal assessment raw scores are found in Table 2.

Table 2. Baseline formal assessment raw scores.

Formal Assessments	Baseline
Western Aphasia Battery-Revised (Aphasia Quotient)	61.4/100
Communicative Activities of Daily Living-2	61/100
Pyramids and Palm Trees Test	44/52
Psycholinguistic Assessment of Language Processing in Aphasia	
Subtest 48: Written Word-Picture Matching	39/40
Subtest 51: Word Semantic Association	11/15
Subtest 52: Spoken Word-Written Word Matching	15/15
Cognitive Linguistic Quick Test	
Symbol Cancellation	0/12
Clock Drawing	7/13
Symbol Trails	10/10
Generative Naming	1/9
Design Memory	2/6
Mazes	0/8
Design Generation	2/13
Wisconsin Card Sorting Test	81/128
Burden of Stroke Scale	Participant: 18 Spouse: 21

[a] Communicative Activities of Daily Living-2 baseline score was an average of three test scores.

[b] Burden of Stroke Scale scores ranged from 10-50. Higher scores indicated a more severe perceived impairment.

Materials

Study materials included formal assessments and experimental stimuli. Administration of formal assessments characterized the participant's speech, language, and cognitive skills prior to intervention, and measured change post-intervention. Specifically, the formal assessments evaluated general communication skills, semantic abilities, cognitive skills, and the participant's and her spouse's perception of her communication impairments.

Formal assessments. Formal assessments included the *Western Aphasia Battery-Revised* (*WAB-R*) (Kertesz, 2006), *Communicative Activities of Daily Living-2* (*CADL-2*) (Holland, Frattali, & Fromm, 1999), *Pyramids and Palm Trees Test* (*PPT*) (Howard & Patterson, 1992), *Psycholinguistic Assessment of Language Processing in Aphasia* (*PALPA*) Subtests (Kay, Colthart, & Lesser, 1992), *Cognitive Linguistic Quick Test* (*CLQT*) Subtests (Helm-Estabrooks, 2001), *Wisconsin Card Sorting Test* (*WCST*) (Grant & Berg, 2003), and the *Burden of Stroke Scale* (*BOSS*) communication domain (Doyle et al., 2004).

Western Aphasia Battery-Revised. The *WAB-R* is an instrument used to assess the linguistic function of adults to determine the presence, type, and degree of aphasia. The researcher administered the *WAB-R* to obtain the participant's Aphasia Quotient (AQ), which was established through the participant's performance on the spontaneous speech, auditory comprehension, word finding, and repetition sections.

Communicative Activities of Daily Living-2. The *CADL-2* provided information about the functional aspects of the participant's communication, including reading, writing, social interactions, sequential relationships, humor, absurdity, divergent communication, use of contextual communication, and non-verbal communication. Additionally, modified scoring of the *CADL-2*, as described by Purdy and Koch (2006), was used as a measure of the participant's switching behavior during functional communication tasks.

Pyramids and Palm Trees Test. The three-picture version of the *PPT* assessed the participant's ability to access semantic and conceptual information from assessment target pictures. When presented with a black and white line drawing, the participant selected which of three pictures was semantically related to the target.

Psycholinguistic Assessment of Language Processing in Aphasia. The *PALA* Subtests further described the participant's semantic skills. Subtest 48: Written Word-Picture Matching, assessed the participant's semantic comprehension of written stimuli. Subtest 51: Word Semantic Association, evaluated the participant's ability to select the word that was semantically related to the orthographic target. Subtest 52: Spoken Word-Written Word Matching required the participant to indicate the written word (out of a field of four) that matched the word the researcher verbally presented.

Cognitive Linguistic Quick Test. The *CLQT* Subtests were administered to describe the participant's cognitive skills in the domains of executive functions, attention, and visuospatial skills. Subtests included: Symbol Cancellation, Clock Drawing, Symbol Trails, Generative Naming, Design Memory, Mazes, and Design Generation. The *CLQT* Design Memory Subtest was administered to serve as a baseline control measure. The Design Memory Subtest primarily assessed memory and visuospatial skills, all of which were hypothesized to not change due to intervention. That is, SFA+MCP was intended to improve word retrieval and switching behavior, not memory and visuospatial skills.

Wisconsin Card Sorting Test. The *WCST* provided a measure of cognitive flexibility. Specifically, the *WCST* examined perseveration, abstract thinking, strategic planning, and executive functions. The participant was presented with four stimuli cards containing different colored symbols and with a stack of similar cards. The participant matched the stack of cards with the stimuli cards based on the symbol type, the symbol color, or the number of symbols.

Burden of Stroke Scale. The *BOSS* examines participant-reported and caregiver-reported difficulty in a number of stroke-related domains including communication, cognition, and life satisfaction. For the current study, only the communication domain was assessed.

Study stimuli. Stimuli were used during baseline, probe, intervention, and post-intervention, sessions. Stimuli included 30 target words divided into three lists. Each target word was represented by three image sets. Additionally, index cards containing orthographic representation of semantic features for the treated target words were provided. The participant had access to a pen and paper as needed throughout the study.

Target words. Thirty nouns were selected, and randomly divided into three balanced lists of 10 words each. The word lists were balanced based on frequency of occurrence (Francis & Kucera, 1982), naming reaction time (http://elexicon.wustl.edu/), number of syllables, and complexity of communication modality production. Complexity of modality production included the ease of gesture production (one-handed or two-handed) and the number of steps needed to draw the word. The word lists contained 13-14 syllables per list, 24-26 steps to draw the words on each list, and 4-5 words that required two-handed gestures per list. Complexity of modality production was determined by the researcher and confirmed by a speech-language pathologist familiar with modality interventions.

The first word list (i.e., treated list one) was treated during phase one of intervention, the second word list (i.e., treated list two) was probed, and the third word list (i.e., untreated list three) was probed every-other intervention session. Following completion of phase one of intervention, the second word list (i.e., treated list two) was treated, the first word list (i.e., treated list one) was probed, and the third word list (i.e., untreated list three) was probed every-other intervention session. The third word list (i.e., untreated list three) was not treated during intervention to provide a measure of generalization to untreated words, and to control for frequent probing of word lists. The word lists treated and probed during each phase are displayed in Table 3.

Table 3. Word lists and study phase chart.

Word List	Phase One	Phase Two
1	Treat	Probe
2	Probe	Treat
3	Probe Every-Other	Probe Every-Other

Images. Each of the 30 target words was represented visually by three image sets: one set of colored photographs and two sets of colored line drawings. The set of 30 colored photographs was used by the participant during RCT probes, and during modified SFA intervention. The first set of 30 colored line drawings was used during CNT probes, and during MCP intervention. The second set of 30 colored line drawings was used by the communication partner during the RCT probes, and by the participant during SFA homework. The colored photographs and colored line drawings were derived from Rossion and Pourtois's (2004) modified Snodgrass and Vanderwart (1980) drawings. Similar images were found on the Internet. Table 4 contains information about the use of each image set during various study tasks and Figure 1 provides examples of the images used during experimental tasks.

Table 4. Use of each image set.

Image Set	Use
Photo Set 1	RCT (Participant)
Photo Set 1	SFA Intervention
Line Drawing Set 1	CNT
Line Drawing Set 1	MCP Intervention
Line Drawing Set 2	RCT (Communication Partner)
Line Drawing Set 2	SFA Homework

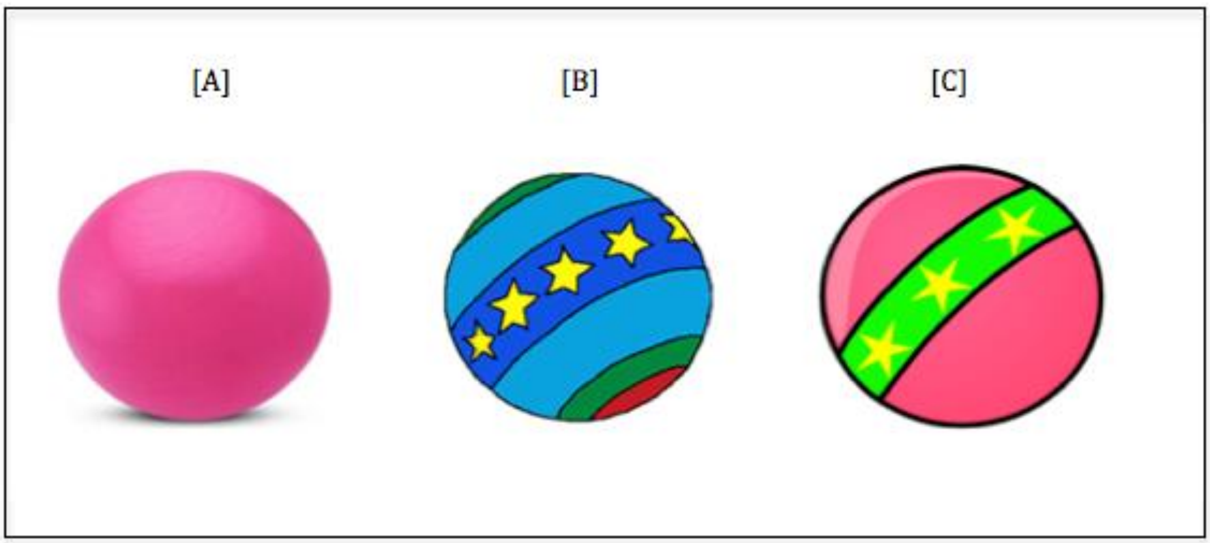

Figure 1. Example of study images. One set of colored photographs (1A), and two sets of colored line drawings (1B and 1C).

SFA stimuli. During modified SFA intervention (described in Procedures), the researcher used the colored photographs, a semantic chart, and index cards containing text representations of semantic features for each target word. The semantic chart was used as a visual cue during modified SFA intervention. Action, use, association, location, description, and category were orthographically represented on the semantic chart. Eight semantic features for each target word were represented on 4X6 inch white index cards in black 20 point Arial font text. Semantic features were based on those identified by Barr and Caplan (1987) and those generated by the researcher and a speech-language pathologist familiar with semantic feature interventions. Various types of semantic features **(**e.g., action, use, association, location, description, category) were used for each target word. Figure 2 provides an example of an index card containing a semantic feature, and a semantic feature chart.

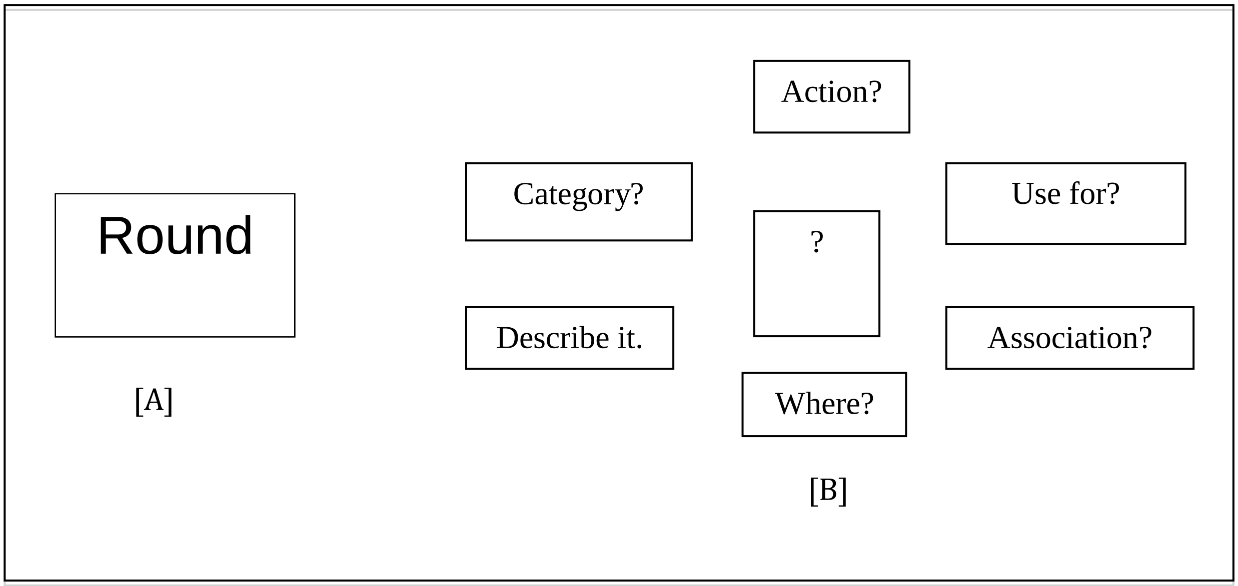

Figure 2. Example of an index card containing a semantic feature (2A), and a semantic feature chart (2B).

Listener task stimuli. During the listener task (described in Procedures), the undergraduate student naïve listeners watched six video-recorded study sessions. The listeners used a sheet of paper containing 60 words (30 targets and 30 semantic foils), and a sheet of paper numbered from 1 to 30. The participants had access to a pen and paper as needed throughout the task.

Procedures

The study was conducted at the Duquesne University Speech-Language-Hearing Clinic and at the participant's home. The study included screening, baseline, probe, intervention, and post-intervention sessions. The researcher used augmented input (i.e., writing keywords, providing photographs, and gesturing) during experimental tasks to increase the participant's comprehension of instructions during probes and intervention tasks. Figure 3 provides a study schedule and Table 5 contains a schedule of the tasks within the study session

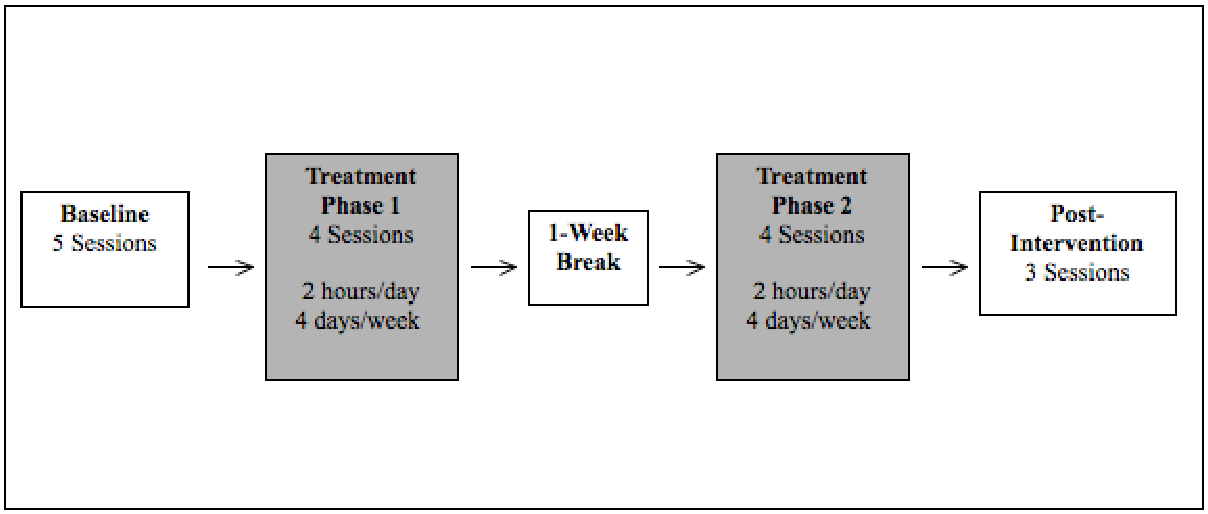

Figure 3. Study schedule.

Table 5. Schedule of tasks within study sessions.

Screening/Baseline 1	Baseline 2	Baseline 3	Baseline 4
• Medical Interview • *WAB-R* • *PPT* • *BOSS* • Baseline CNT (1) • Baseline RCT (1)	• *CADL-2* (1) • *PALPA* • Baseline CNT (2) • Baseline RCT (2)	• *CADL-2* (2) • *CLQT* • Baseline CNT (3) • Baseline RCT (3)	• *CADL-2* (3) • *WCST* • Baseline CNT (4) • Baseline RCT (4)
Treatment 1 Phase 1	Treatment 2 Phase 1	Treatment 3 Phase 1	Treatment 4 Phase 1
• Baseline CNT (5) • Baseline RCT (5) • SFA+MCP, Treated List 1	• CNT Probe (1) • RCT Probe (1) • SFA+MCP, Treated List 1	• CNT Probe (2) • RCT Probe (2) • SFA+MCP, Treated List 1	• CNT Probe (3) • RCT Probe (3) • SFA+MCP, Treated List 1
Treatment 1 Phase 2	Treatment 2 Phase 2	Treatment 3 Phase 2	Treatment 4 Phase 2
• CNT Probe (4) • RCT Probe (4) • SFA+MCP, Treated List 2	• CNT Probe (5) • RCT Probe (5) • SFA+MCP, Treated List 2	• CNT Probe (6) • RCT Probe (6) • SFA+MCP, Treated List 2	• CNT Probe (7) • RCT Probe (7) • SFA+MCP, Treated List 2
Post-Intervention 1	Post-Intervention 2	Post-Intervention 3	
• CNT Probe (1) • RCT Probe (1) • *WAB-R* • *CLQT*	• CNT Probe (2) • RCT Probe (2) • *CADL-2*	• CNT Probe (3) RCT Probe (3) • *WCST*	

Screening session. Prior to beginning baseline sessions, the participant completed screening procedures to confirm that she met study criteria. The researcher conducted a medical history interview to determine pre-morbid speech, language, or cognitive impairments, hearing or vision difficulties, and handedness. Additionally, the *WAB-R* Auditory Word Recognition Subtest and an experimental CNT were administered.

Baseline sessions. Following the screening session, the participant completed five baseline sessions. Four baseline sessions were concluded pre-treatment, and one baseline session was completed during the first intervention session. Formal assessments administered during baseline sessions included the *WAB-R*, *PPT*, *PALPA* Subtests, *CLQT* Subtests, *WCST*, and the *BOSS*. Each assessment was conducted once during one of the first four baseline sessions. The *CADL-2* was administered three times, across three of the first four baseline sessions. Additionally, the participant completed a CNT and a RCT during each baseline session.

Confrontation naming task. In addition to formal assessments, a CNT containing the 30 treated and untreated words from the three word lists was completed during each of the five baseline sessions. The CNT was used to assess the participant's word retrieval accuracy, and as the result of an unexpected finding, the participant's use of correct non-verbal modalities. During the CNT, the researcher showed the participant the 30 randomized line drawings, and asked the participant "what is this?". The participant was given 15 seconds to produce an accurate response before the researcher presented the next line drawing.

Referential communication task. Following the CNT, the participant completed a RCT including the 30 treated and untreated words from the three word lists during each of the five baseline sessions. The RCT was used to assess the participant's switching behavior, as well as accuracy of first and second modality productions. Performance on the first five referential communication tasks (during baseline sessions) additionally determined the participant's three most frequently used communication modalities. Possible communication modalities included gesturing, drawing, writing, and speaking. The three most frequently used communication modalities were targeted during subsequent RCT probes and intervention sessions.

The RCT included the participant, the researcher, and a communication partner. Before the task, the communication partner was provided with a line drawing of each of the 30 words, and a randomized list of the 30 words. To provide opportunities for the participant to switch modalities, the list contained 15 randomly selected words (i.e., five words from each of the three word lists) that served as words the communication partner provided to the participant as incorrect, regardless of the participant's response. Therefore, switching behaviors by the participant were elicited for at least 50% and up to 100% of the trials. The communication partner was blind to whether the word was from the treated or untreated word lists. During each probe, the 30 words were randomized to create a new word order.

To begin each probe, the participant was instructed as follows: "I am going to show you a picture. The communication partner has a similar picture in her stack of pictures. You should help her match the pictures. You will ask her for the matching picture in any way that you can. If she misunderstands, she will show you the wrong picture. You can help her understand". The researcher presented the participant with a photograph depicting 1 of the 30 concepts. The communication partner was not able to view the photograph. Following production of the concept by the participant, the communication partner provided the participant with a correct or incorrect line drawing, dependent on the response of the participant, and on whether or not the word was predetermined to provide a switching opportunity.

Three possible responses by the communication partner existed:

1. If the concept was predetermined to offer a line drawing based on the participant's response, and the participant responded *correctly*, the communication partner presented the *correct* line drawing. The researcher then provided the next photograph to the participant.

2. If the concept was predetermined to offer a line drawing based on the participant's response, and the participant responded *incorrectly*, the communication partner presented the *incorrect* line drawing. This was considered an opportunity to switch modalities. If the participant did not recognize that the presented line drawing was incorrect, and did not switch

modalities to correct the response, following 5 seconds the response was considered a failed attempt to switch modalities. The researcher then provided the next photograph to the participant.

3. If the concept was predetermined to provide a switching opportunity, and the participant responded *correctly*, the communication partner presented the *incorrect* line drawing. The communication partner did not indicate that the incorrect image was provided. This scenario was also considered an opportunity to switch modalities. If the participant did not recognize that the presented line drawing was incorrect, and did not switch modalities to correct the response, following 5 seconds the response was considered a failed attempt to switch modalities. The researcher then provided the next photograph to the participant.

Probe sessions. The participant completed a probe session at the beginning of each intervention session. Probe sessions included the CNT and the RCT. During phase one and phase two of intervention, word list one (i.e., treated list one) and word list two (i.e., treated list two) were probed every intervention session, and word list three (i.e., untreated list three) was probed every-other intervention session.

During treatment phase one, the researcher noted that the participant may not have fully comprehended or remembered the RCT instructions (as described in Discussion). As a result, the RCT was modified to increase the participant's understanding and recalling of the task instructions, and to potentially provide the researcher with an improved measure of the participant's switching behavior. During the modified RCT, the communication partner (blind to whether the word was from the treated or untreated word lists) presented the line drawing to the participant, and prompted the participant to communicate the concept "in any way that you can". Following communication of the concept by the participant, the communication partner did not provide the participant with a correct or incorrect line drawing. Instead, the communication partner offered the participant indirect verbal and non-verbal cues. For example, the communication partner nodded, or said "is there anything else you can do to help me understand?". Additionally, a visual cue card of the task instructions was utilized to increase the participant's comprehension and memory of the RCT instructions. The researcher reviewed the task instructions with the participant multiple times throughout each RCT probe.

Intervention sessions. The 2-hour intervention sessions were completed across two phases. Each treatment phase lasted 4 days (8 total days of treatment). Phase one included the 10 words on the first word list (i.e., treated list one) and phase two included the 10 words on the second word list (i.e., treated list two). Each word was treated separately, during a two-step process. Semantic intervention followed by multimodal intervention was completed for one word, prior to completion of the two-step process for the subsequent word. The final component of treatment was homework to be completed by the participant each day during the two treatment phases.

Semantic feature analysis. Semantic feature treatment was the first step of the experimental intervention. The treatment was similar to a traditional semantic feature analysis with modifications to emphasize participant generation of semantic features. First the participant was presented with a photograph of each target word and with a semantic feature chart. The researcher asked the participant to describe the target word using the semantic chart as a visual cue. If the participant self-generated four or more semantic features, the researcher confirmed the features by verbally repeating them and by writing them in the semantic chart. Once the participant generated the features, the researcher asked, "Can you tell me anything else?" If the participant provided fewer than four features, the researcher confirmed the features and provided traditional SFA cueing (e.g., "what is it used for?) for features the participant did not provide. If a feature was not provided in response to SFA cueing, the researcher provided the feature. SFA cueing continued until four features were generated, and confirmed. Non-verbal responses were scaffolded into verbal responses, and incorrect responses were corrected. Following self-generated and SFA cued responses, the researcher presented the participant with four additional predetermined semantic features preceded by traditional SFA cues. Once verbally presented, the researcher wrote the predetermined features in the semantic chart. Following presentation of the predetermined features, the researcher reviewed each feature (self-generated and predetermined) by pointing to the written feature and requesting verbal production from the participant. Finally, the researcher asked the participant to name the target word. If the participant did not name the target within 15 seconds, the researcher provided a phonemic cue, a text cue, or a model and asked the participant to repeat the target.

M***ultimodal communication program (MCP).*** Following modified SFA intervention for the target word, MCP intervention was completed for the same target word. To reduce the cognitive demand placed on the participant, and to maximize the effects of the treated modalities, the participant was treated in the three modalities she produced during baseline sessions. The treated modalities included speaking, gesturing, and drawing.

During MCP, the participant was presented with a line drawing of a target concept. The researcher modeled each modality (speaking, gesturing, and drawing) and instructed the participant on how to produce each of the three modalities. The participant then imitated each modality. Following the initial treating of each modality, the researcher and the participant reviewed all modalities. To review, the researcher prompted the participant by requesting that she "show all the ways you can communicate this". If a modality was not produced, the researcher asked the participant, “how else can you show me?” to prompt for additional modalities. If the participant did not produce all modalities within 30 seconds, the participant was explicitly instructed to produce the modality (e.g., “gesture it”) and was provided cues as needed. The order of modality instruction for each target word was randomized for each intervention session to control for potential threats to validity, including order effect and learning.

Following SFA and MCP intervention for one target word, the two-step intervention process was repeated for the subsequent target concept, until all 10 words on the first word list (i.e., treated list one) were treated, and phase one of intervention was completed. Phase two followed the same process of intervention for the second word list (i.e., treated list two).

Semantic feature analysis homework. Following each intervention session of treatment phase one and treatment phase two, the participant was prompted to complete 30 minutes of semantically-based homework. The participant was provided with line drawings of the treated words from the specific intervention session and with semantic feature charts. The researcher instructed her to describe each target word individually using the semantic chart as a visual cue.

During the treatment phases, the participant and her husband reported inconsistent adherence to SFA homework instructions. That is, the participant completed the homework only after some of the intervention sessions of treatment phase one and treatment phase two. They also reported that the participant repeated target concepts after her husband, and did not review semantic features for the targets.

Post-intervention sessions. Within 14 days following the final intervention session, three post-intervention sessions were completed at least 24 hours apart from one another. Formal assessments including the *WAB-R*, *CADL-2*, *PALPA* Subtests, *CLQT* Subtests, and the

WCST were re-administered across the three post-intervention sessions. The participant additionally completed the CNT and the RCT during each post-intervention session.

Listener task. Following completion of baseline, intervention, and post-intervention sessions, the researcher conducted a naïve listener task. The task examined naïve listeners' accurate identification of the participant's communication attempts. Eleven undergraduate freshmen speech-language pathology students (naïve listeners) watched six video-recorded RCT probes; three baseline probes, and three post-intervention probes. The listeners viewed the participant's production of verbalizations, gestures, air drawings, and pen-and-paper drawings for each target concept. The researcher provided the listeners with the participant's original drawings. The listeners were instructed to make judgments regarding the concepts the participant was communicating. That is, the listener participants selected the target word from a list of 60 words (containing the 30 target words of the study, and 30 foils) that they believed the participant was communicating. The six videos were watched in random order, and the listeners were blinded to whether the RCT probes were from baseline or post-intervention sessions.

Data Analysis

All study sessions were video-recorded, and all verbal and non-verbal responses during the CNT, RCT, and *CADL-2* were transcribed. Dependent variables, including word retrieval accuracy and switching behavior were measured through the participant's performance on the CNT, RCT, and *CADL-2*. A third dependent variable, listeners' accuracy, was analyzed during a naïve listener task. Data analyses included calculation of effect sizes and completion of visual analyses for the word retrieval accuracy score and the RCT communicative flexibility score. Effect sizes were also calculated for correct non-verbal modality productions as well as for accuracy of initial and second modality productions. Additionally, formal assessments completed during baseline and post-intervention were analyzed. Finally, the researcher calculated reliability and treatment fidelity. The following sections describe the analyses of dependent variables, formal assessments, reliability and treatment fidelity.

Confrontation naming task analysis. The participant's performance on the CNT provided two types of data: 1) Word retrieval accuracy score and 2) Number of correct non-verbal modalities.

Word retrieval accuracy score. The word retrieval accuracy score was analyzed to answer Research Question One: Does implementation of SFA+MCP affect the accuracy with which a person with PPA retrieves words? Accurate responses included target words verbally produced by the participant within 15 seconds of the presentation of the image. Stability during baseline was defined as a word retrieval accuracy score ranging by two or fewer words per word list.

Effect size. The effect size was calculated as described by Beeson and Robey (2006). Small, medium, and large effect sizes were cited as 4.0, 7.0, and 10.1 respectively. First, scores from baseline sessions were averaged to represent (A_1), and calculated to determine the standard deviation (S_1). Then, scores obtained from post-intervention measures were averaged (A_2). The following formula was used to calculate effect size:

$$Effect\ Size = \frac{A_2 - A_1}{S_1}$$

Visual analysis. Visual analyses, described by Kratochwill and colleagues (2010), which included examination of predictable baseline pattern, level, trend, variability, immediacy of the effect, degree of overlap, and consistency of data patterns, were used to determine the presence and magnitude of the relationship between SFA+MCP and word retrieval accuracy during the CNT. The visual analysis was completed for each of the three word lists separately.

The researcher and a speech-language pathologist familiar with SFA interventions examined the predictable baseline pattern. The baseline pattern for the word retrieval accuracy score was determined to be stable across five baseline CNT probes prior to initiating intervention. The mean of all of the data points within a phase (baseline, treatment phase one, treatment phase two, and post-intervention) was calculated to determine the level. The trend was measured as the best-fit line of the data points within each phase. Variability was described as the variation or the standard deviation of the data around the mean. Ovals, rectangles, and triangles were used to examine the immediacy of effect. The last three shapes of one phase were compared to the first three shapes of the subsequent phase to determine if intervention had an immediate effect on word retrieval accuracy between phases. Degree of overlap was described as the percentage of data points from one phase that overlapped with the data points from the adjacent phase. Consistency across phases was analyzed by comparing the data between similar phases (i.e., baseline and post-intervention; treatment phase one and treatment phase two), to determine if the data between the similar phases differed.

Number of correct non-verbal modalities. The researcher observed that the participant produced non-verbal modalities during word retrieval attempts throughout the CNT. As a result, examination of non-verbal modalities was used to determine if the production of correct non-verbal modalities during the CNT improved following SFA+MCP.

Effect size. The effect size was calculated as described by Beeson and Robey (2006). First, scores from baseline sessions were averaged to represent (A_1), and calculated to determine the standard deviation (S_1). Then, scores obtained from post-intervention measures were averaged (A_2).

Referential communication task analysis. RCT performance provided three scores: 1) The communicative flexibility score, 2) The accuracy of initial modality productions, and 3) The accuracy of second modality productions.

Communicative flexibility score. The communicative flexibility score was analyzed to answer Research Question Two: Does implementation of SFA+MCP affect the ability of a person with PPA to switch among modalities when an initial communication attempt fails? The communicative flexibility score reflected the participant's switching behavior. Specifically, switching was defined as the participant's accurate production of a different modality to repair a breakdown resulting from the initial production of a concept. For example, if the participant incorrectly gestured the concept *cat*, and then correctly drew the concept *cat*, it was considered a successful switch.

Effect size. The effect size was calculated as described by Beeson and Robey (2006). First, scores from baseline sessions were averaged to represent (A_1), and calculated to determine the standard deviation (S_1). Then, scores obtained from post-intervention measures were averaged (A_2).

Visual analysis. Visual analyses as described by Kratochwill and colleagues (2010), which included examination of predictable baseline pattern, level, trend, variability, immediacy of the effect, degree of overlap, and consistency of data patterns (described above), were used to determine the presence and magnitude of the relationship between SFA+MCP and switching behavior during the RCT.

Accuracy of initial and second modality productions. The accuracy of initial and second modality productions was included as descriptive information about the participant's productions of different modalities. The accuracy of initial modality productions was determined by adding the number of correct modalities (verbal and non-verbal) following the participant's first attempt at production of the concept. The researcher calculated the accuracy of second modality productions by dividing the number of accurate second modality productions (verbal and non-verbal) by the number of second modality attempts during RCT probes. Accuracy of initial and second modality productions was computed for each word list.

Effect size. The effect size was calculated as described by Beeson and Robey (2006). First, scores from baseline sessions were averaged to represent (A_1), and calculated to determine the standard deviation (S_1). Then, scores obtained from post-intervention measures were averaged (A_2).

Communicative Activities of Daily Living-2 modified scoring analysis. The participant's performance on the *CADL-2* provided a communicative flexibility score. The communicative flexibility score was analyzed to answer Research Question Three: Does implementation of SFA+MCP affect the communicative flexibility score of a person with PPA during administration of the *CADL-2*? As described by Purdy and Koch (2006), switching behavior was measured by analysis of the participant's responses on specific questions of the assessment. The *CADL-2* communicative flexibility score was calculated in the same manner as the RCT communicative flexibility score.

Effect size. The effect size was calculated as described by Beeson and Robey (2006). First, scores from baseline sessions were averaged to represent (A_1), and calculated to determine the standard deviation (S_1). Then, scores obtained from post-intervention measures were averaged (A_2).

Listener task analysis. The listener task analysis provided a listeners' accuracy score. The listeners' accuracy score was used to answer Research Question Four: Do naïve listeners identify the participant's communication attempts with greater accuracy following SFA+MCP? Accurate responses included the listeners' correct identification of the participant's communication attempts. A graph was plotted to depict each listener's individual responses across all six sessions included in the listener task.

A t-test was used to compare naïve listeners' identification accuracy between baseline and post-intervention RCT probes. To compute the t-test, each listener's number of accurate responses was averaged across three baseline sessions and three post-intervention sessions.

Formal assessment analysis. Formal assessment results were evaluated during baseline and post-intervention to determine the participant's change in performance following intervention. Assessments included: the *WAB-R* (Aphasia Quotient), *CADL-2*, *PALPA* Subtests, *CLQT* Subtests, and *WCST*.

Inter-rater reliability. A graduate speech-language pathology student familiar with SFA interventions and non-verbal modalities completed inter-rater reliability for 4 out of 15 randomly selected CNT probes (26.67% of the sample). The student was instructed on scoring procedures and used an Excel© sheet, identical to the one used by the researcher, to complete inter-rater reliability. The student was blind to whether the words were treated or untreated. Initially, the researcher and the graduate speech-language pathology student completed scoring of the sample separately. Agreement between the researcher and the student for the word retrieval accuracy score was 99.17%, and agreement for the number of correct non-verbal modalities was 85%. Discrepancies were resolved through discussion prior to the final analysis.

Inter-rater reliability was also completed for randomly selected RCT probes by a graduate speech-language pathology student familiar with MCP interventions. Agreement between the researcher and the student for the communicative flexibility score was 86.25%. Agreement for accuracy of initial modality productions was 93.33% and agreement for accuracy of second modality productions was 89.17%. Prior to the final analysis, discrepancies were resolved through discussion.

Treatment fidelity. A graduate speech-language pathology student completed treatment fidelity for four out of eight intervention sessions (50% of the sample). To determine treatment fidelity, the student used the same list of guidelines followed by the researcher throughout intervention (e.g., teach three target modalities during MCP intervention). Treatment fidelity was 99.17%.

CHAPTER III

Results

This study examined the effects of SFA+MCP on the participant's word retrieval accuracy during confrontation naming task (CNT) probes, as well as switching among modalities when an initial communication attempt failed during referential communication task (RCT) probes, and during *CADL-2* administrations. Additionally, this study investigated the effects of SFA+MCP on naïve listeners' identification of the participant's communication attempts. First, the participant's performance during the CNT is described, including word retrieval accuracy and correct non-verbal productions. Second, the participant's performance during the RCT is explained, including switching behavior and accuracy of initial and second modality productions. Third, the participant's switching during the *CADL-2* is described. Fourth, the naïve listeners' performance during the listener task is included. Finally, description of formal assessment scores is provided.

Results of Dependent Variables

Research question one. The purpose of Research Question One was to investigate the effects of SFA+MCP on word retrieval accuracy during the CNT. In addition to the word retrieval accuracy score, correct non-verbal productions during the CNT were recorded.

Word retrieval accuracy score. The researcher calculated the word retrieval accuracy score for each CNT probe, and the effect size was computed for each word list (Beeson & Robey, 2006). SFA+MCP resulted in no statistically significant effect size for treated list one (d=0.94), treated list two (d=-0.12), and untreated list three (d=-0.94). The scores for the three word lists are presented in Figure 4, and the effect size for each word list is provided in Table 6.

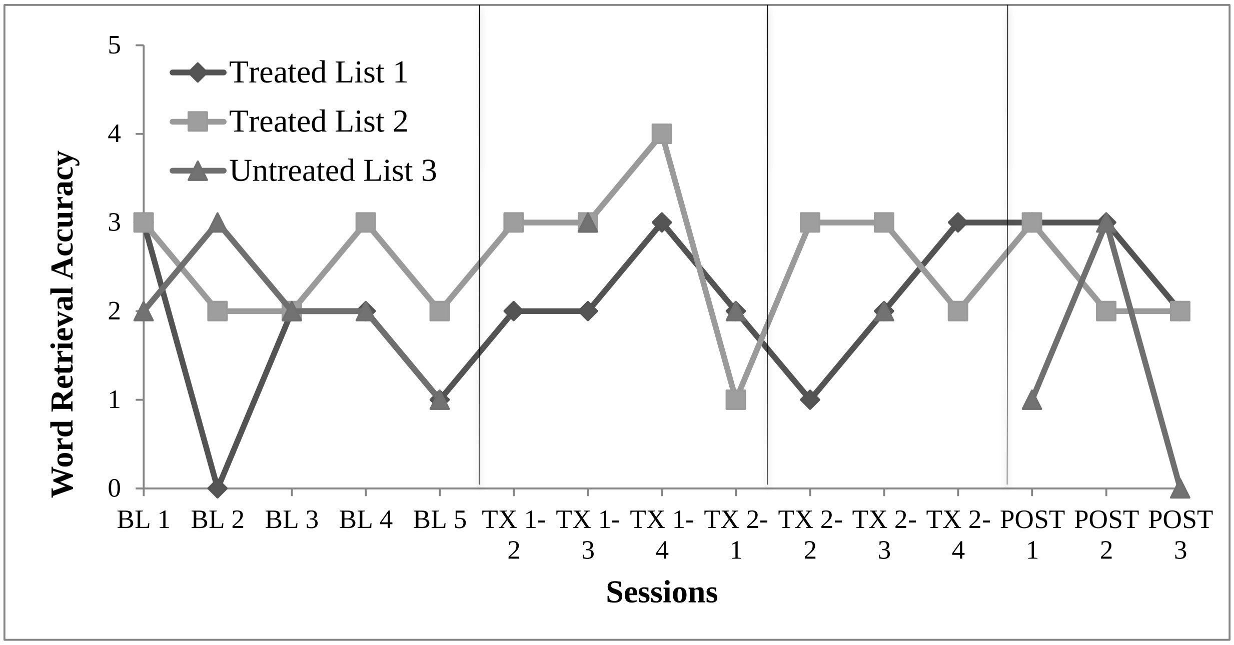

Figure 4. Participant's word retrieval accuracy scores for each word list.

Table 6. Treatment effect of SFA+MCP on word retrieval accuracy during CNT.

Word List	Effect Size
1	0.94 (No Effect)
2	-0.12 (No Effect)
3	-0.94 (No Effect)

Visual analysis. Visual analyses, as described by Kratochwill and colleagues (2010), including the predictable baseline pattern, level, trend, variability, immediacy of the effect, degree of overlap, and consistency across phases are described in the following sections.

Predictable baseline pattern. The researcher determined the naming accuracy baseline pattern through analysis of the word retrieval accuracy score. The participant's word retrieval accuracy did not range by more than two concepts per list during three consecutive baseline sessions, indicating a stable baseline pattern.

Level. Level is the mean of all of the data points within a phase. The mean word retrieval accuracy score for treated list one was 1.6 out of 10 at baseline, 2.25 out of 10 during treatment phase one, 2 out of 10 during treatment phase two, and 2.67 out of 10 at post-intervention. For treated list two, the mean was 2.4 out of 10 at baseline, 2.75 out of 10 during treatment phase one, 2.67 out of 10 during treatment phase two, and 2.33 out of 10 at post-intervention. The mean for untreated list three was 2 out of 10 at baseline, 2.5 out of 10 during treatment phase one, and 1.3 out of 10 at post-intervention. The mean for untreated list three during treatment phase two could not be calculated because only one data point existed (i.e., 2 out of 10). The level for each word list is presented in Figure 5.

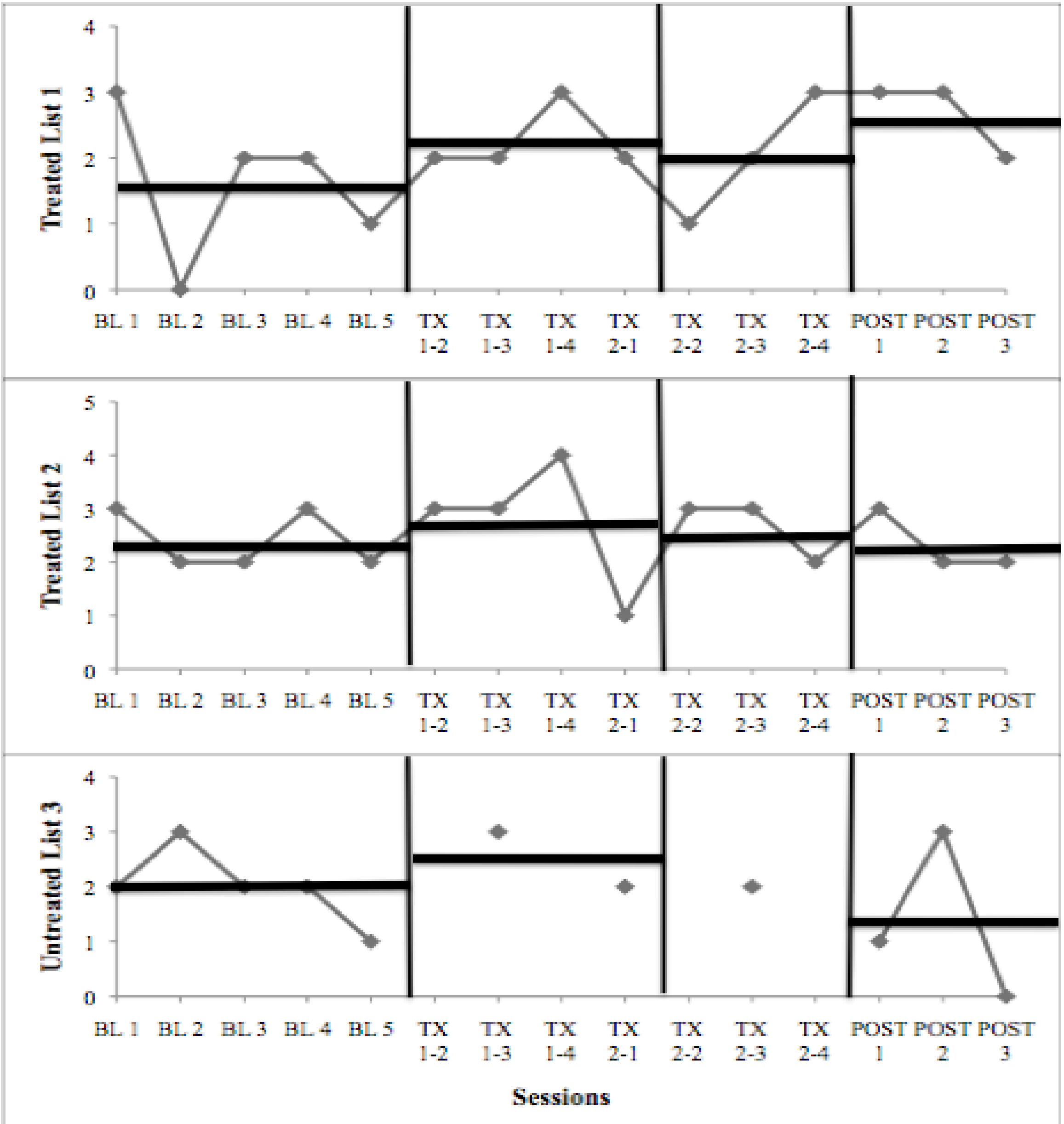

Figure 5. Visual analysis of level for CNT word retrieval accuracy scores.

Trend. The trend line at baseline was zero accelerating for treated list one and treated list two, and was decelerating for untreated list three. During treatment phase one, the trend line was accelerating for treated list one and decelerating for treated list two. Within treatment phase two, the trend line was accelerating for treated list one and decelerating for treated list two. The trend line at post-intervention was decelerating for each of the three word lists. Untreated list three was probed every-other intervention session during treatment phase one and two. Therefore, the trend line for treatment phase one and two of the untreated list could not be calculated. The trend lines for each of the three word lists are represented in Figure 6.

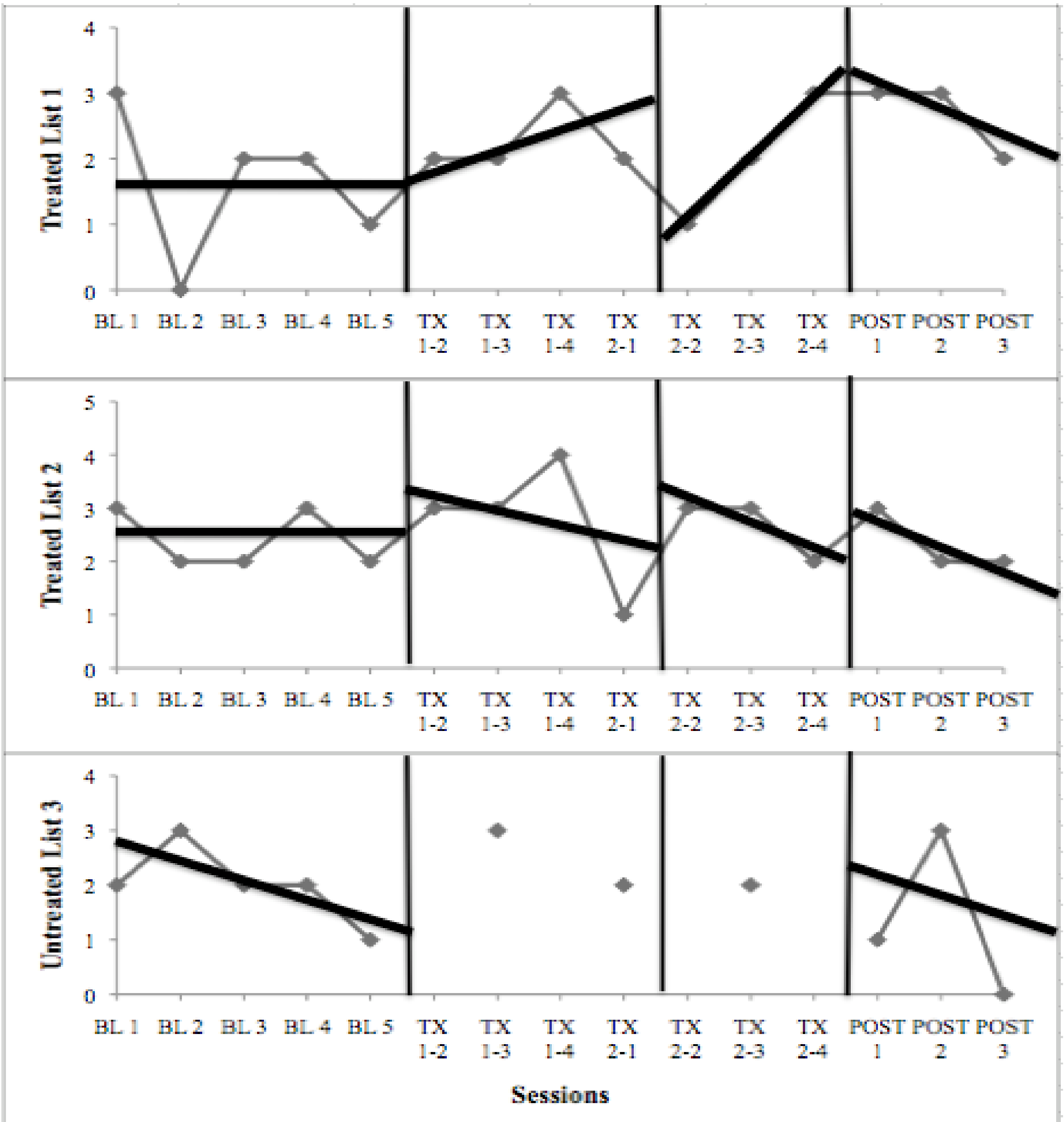

Figure 6. Visual analysis of trend for CNT word retrieval accuracy scores.

Variability. Variability was analyzed during each phase for each word list. At baseline, the standard deviation was 1.14 (M=1.6) for treated list one, 0.55 (M=2.4) for treated list two, and 0.71 (M=2) for untreated list three. Within treatment phase one, the standard deviation was 0.5 (M=2.25) for treated list one, 1.26 (M=2.75) for treated list two, and 0.71 (M=2.5) for untreated list three. During treatment phase two, the standard deviation was 1 (M=2) for treated list one and was 0.58 (M=2.67) for treated list two. Variability could not be calculated for untreated list three because the list was probed only one time within treatment phase two. At post-intervention, the standard deviation was 0.58 (M=2.67) for treated list one, 0.58 (M=2.33) for treated list two, and 1.53 (M=1.33) for untreated list three. Variability for each word list is provided in Figure 7, the dotted lines illustrate the standard deviation and the solid lines portray the mean.

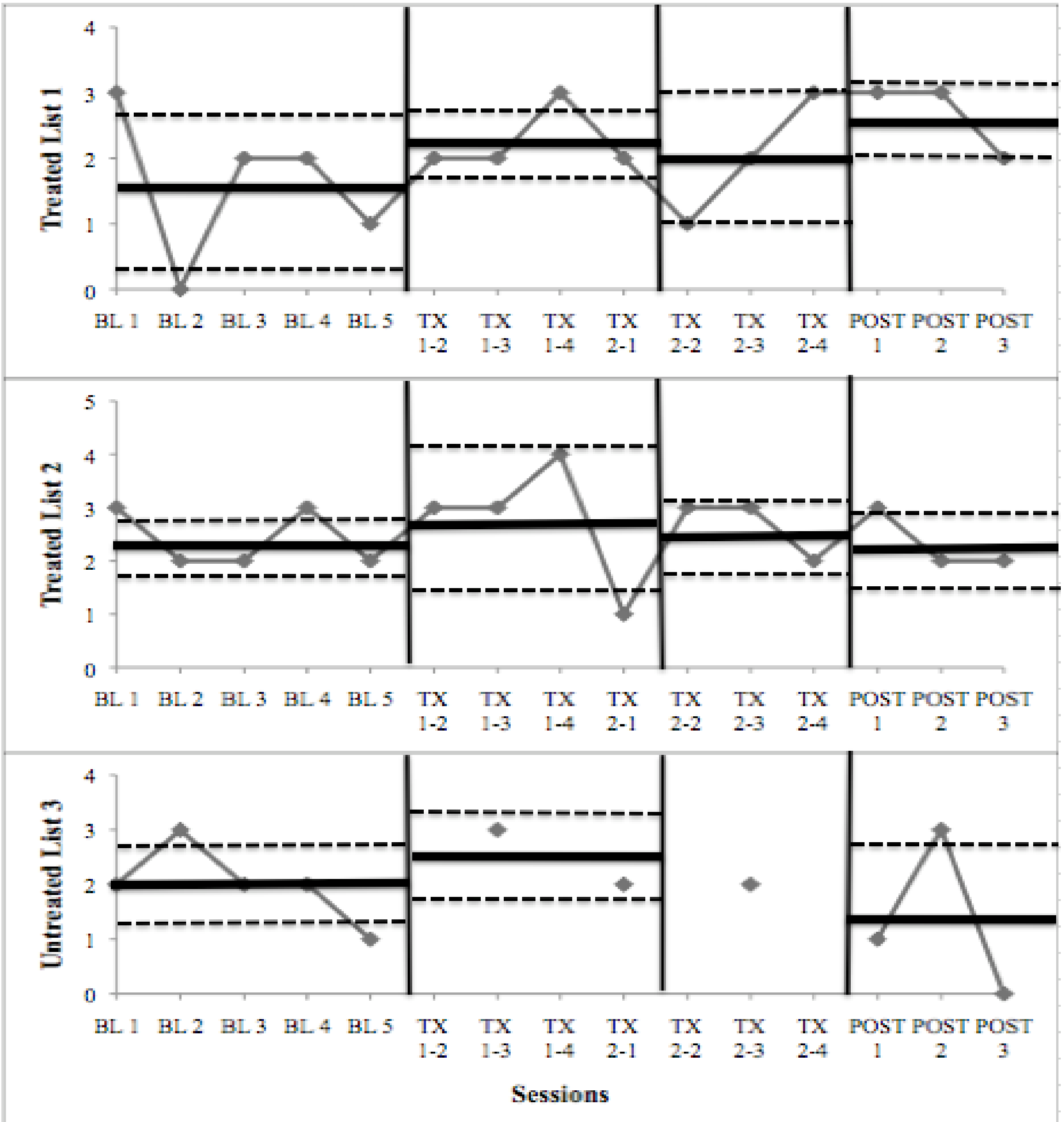

Figure 7. Visual analysis of variability for CNT word retrieval accuracy scores.

Immediacy of the effect. To describe the immediacy of effect, the last three data points of a phase were visually compared to the first three data points of the next phase using shapes (i.e., ovals, rectangles, and triangles). There was an immediate effect of word retrieval accuracy scores between baseline and treatment phase one for treated list one and for treated list two. There was an immediate effect between treatment phase one and treatment phase two for treated list one, and no immediate effect for treated list two. For treated lists one and two there was no immediate effect between treatment phase two and post-intervention. Immediacy of effect for untreated list three could not be determined because the word list was probed every-other intervention session. Immediacy of the effect for word list one and word list two is provided in Figure 8.

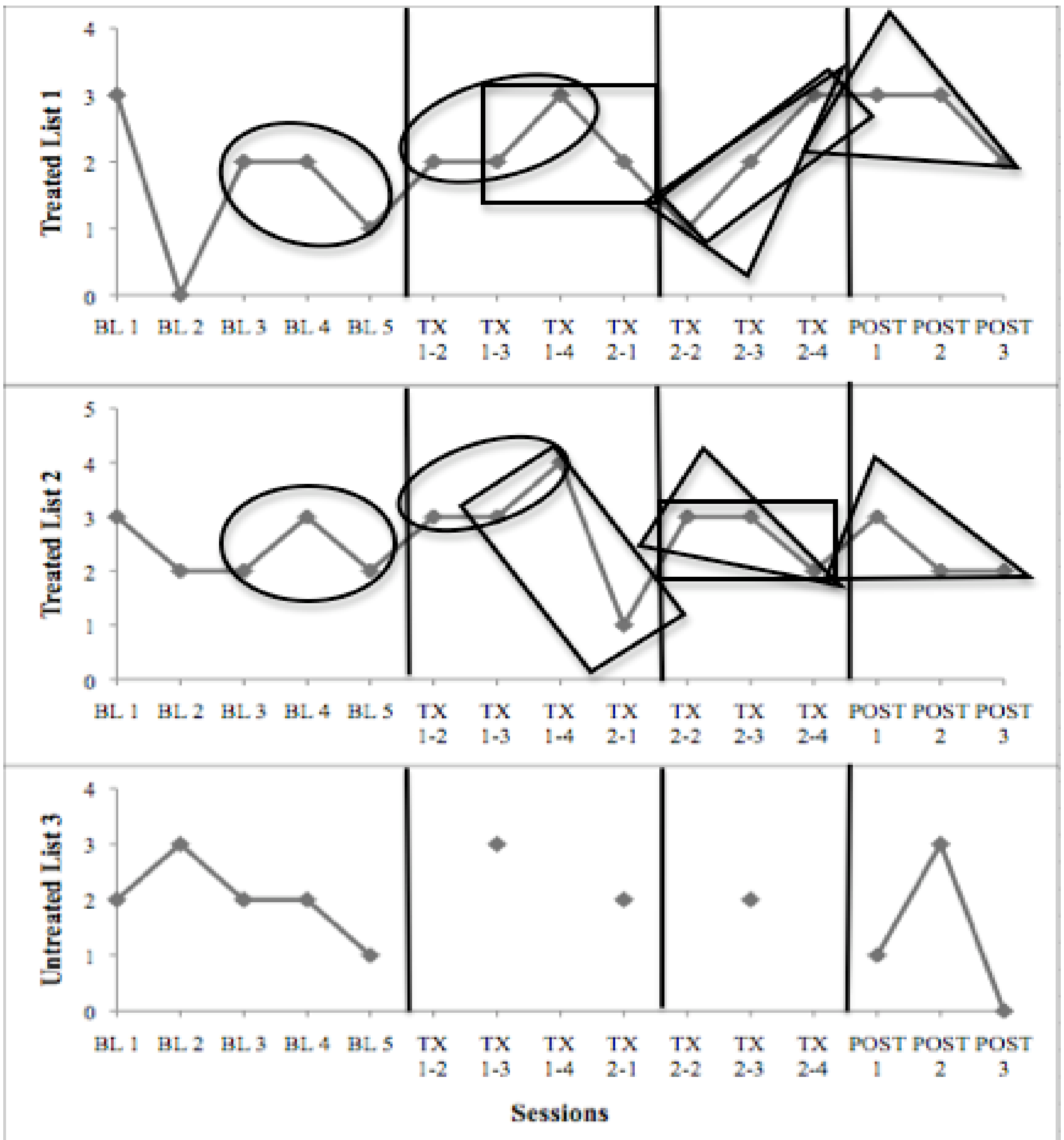

Figure 8. Visual analysis of immediacy of the effect for CNT word retrieval accuracy scores.

Degree of overlap. The degree of overlap between each adjacent phase was analyzed for each of the three word lists. A smaller percentage of overlapping data points was consistent with a greater effect. Between baseline and treatment phase one, treated list one had 4 overlapping data points (100%), treated list two had 3 (75%), and untreated list three had 2 (100%). Between treatment phase one and treatment phase two, treated list one had 3 overlapping data points (100%), treated list two had 3 (100%), and untreated list three had 1 (100%). Between treatment phase two and post-intervention, treated list one had 3 overlapping data points (100%), treated list two had 3 (100%), and untreated list three had 2 (66.67%). Degree of overlap for each of the three word lists is represented in Figure 9.

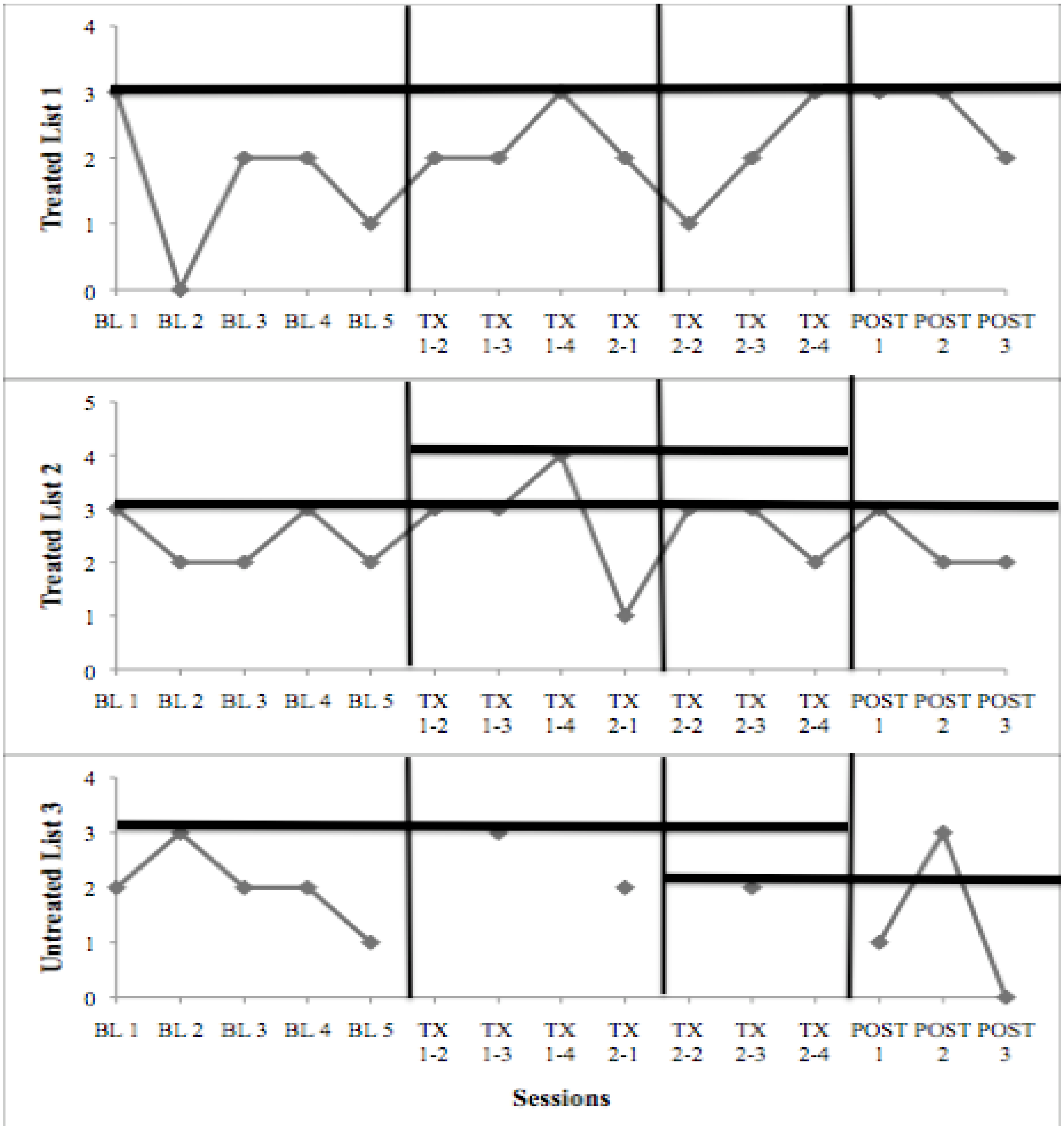

Figure 9. Visual analysis of degree of overlap for CNT word retrieval accuracy scores.

Consistency of data patterns across similar phases. The data patterns between the two treatment phases indicated an inconsistent pattern of word retrieval accuracy for treated list one, and a consistent pattern for treated list two. Consistency between treatment phase one and treatment phase two could not be determined for untreated list three, because the word list was probed every-other intervention session. The data patterns between baseline and post-intervention indicated an inconsistent pattern of word retrieval accuracy for treated list one, a consistent pattern for treated list two, and an inconsistent pattern for untreated list three. Consistency across phases for each word list is represented by the linked ovals in Figure 10.

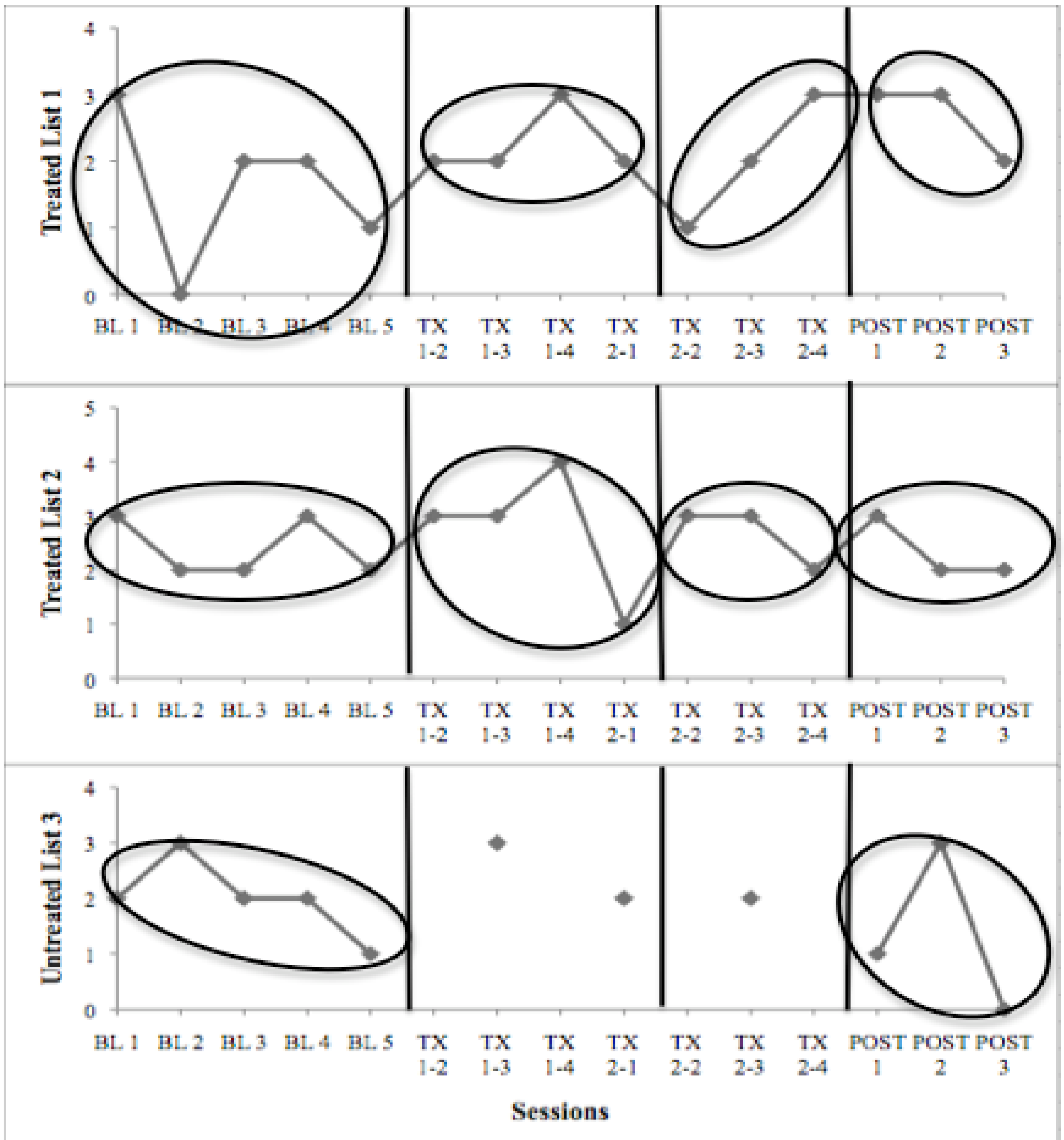

Figure 10. Visual analysis of consistency across phases for CNT word retrieval accuracy scores.

Number of correct non-verbal modalities. The researcher examined the participant's production of correct non-verbal modalities during CNT probes, and the effect size for each of the three word lists was calculated (Beeson & Robey, 2006). SFA+MCP resulted in no statistically significant effect size for treated list one (d=1.04), treated list two (d=0.47), and untreated list three (d=2.28). Number of correct non-verbal modalities for each word list is presented in Figure 11, and the effect size for each word list is provided in Table 7.

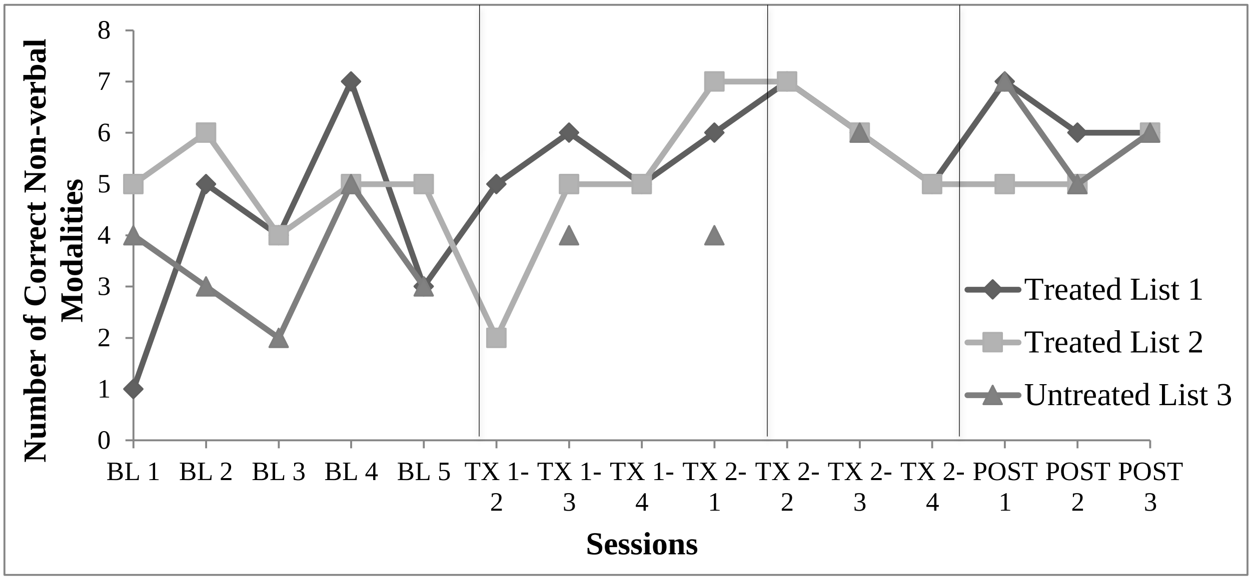

Figure 11. Correct non-verbal modalities during CNT probes.

Table 7. Treatment effect of SFA+MCP on correct non-verbal modalities during CNT.

Word List	Effect Size
1	1.04 (No Effect)
2	0.47 (No Effect)
3	2.28 (No Effect)

Research question two. The purpose of Research Question Two was to examine the effects of SFA+MCP on the ability to switch among modalities when an initial communication attempt failed during the RCT. In addition to the communicative flexibility (i.e., switching) score, the accuracy of the initial and second modality productions was recorded.

Communicative flexibility score. The researcher calculated the communicative flexibility score (represented as a percentage) for each RCT probe by dividing the number of modality switches by the number of opportunities to switch. Modality switches most frequently used by the participant included switching from speaking, to gesturing or air drawing. Overall, the participant exhibited increased switching behaviors during treatment phase two. The researcher calculated the effect size for each word list (Beeson & Robey, 2006). SFA+MCP resulted in a small statistically significant effect size for treated list one (d=4.58), and no statistically significant effect size for treated list two (d=1.41) and untreated list three (d=2.61). The scores for each of the three word lists are represented in Figure 12, and the effect size for each list is displayed in Table 8.

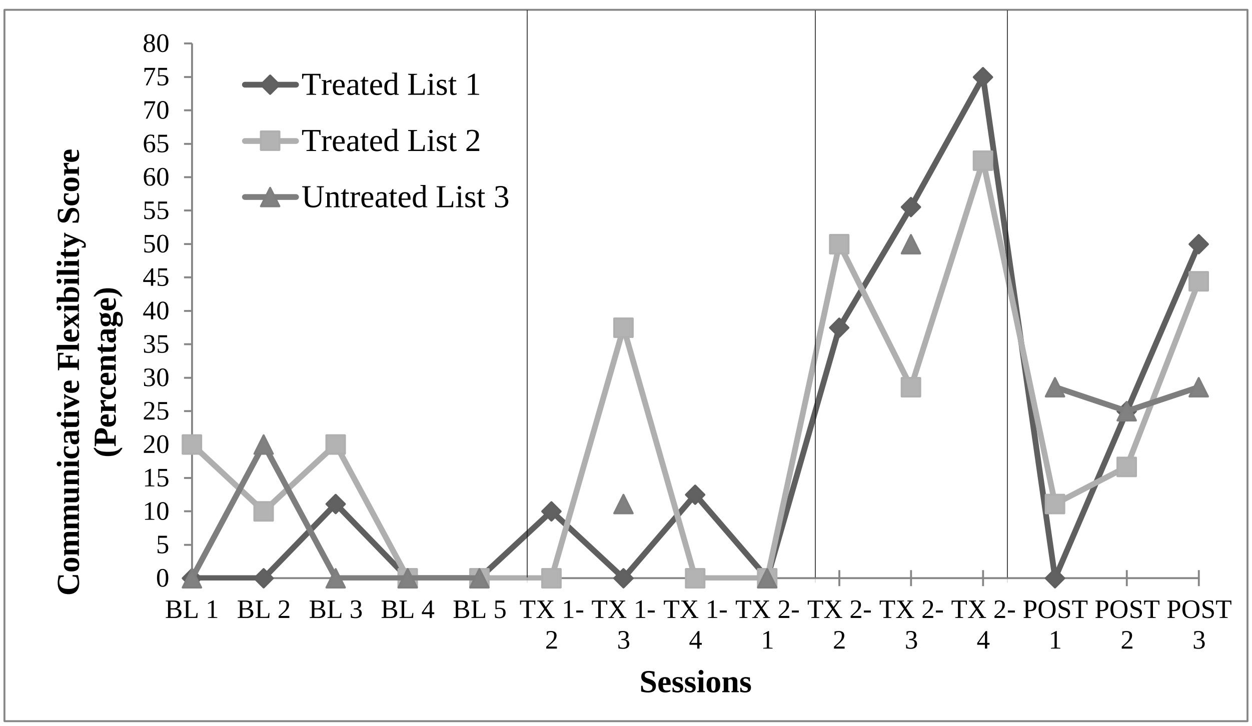

Figure 12. Participant's communicative flexibility scores for each word list.

Table 8. Treatment effect of SFA+MCP on communicative flexibility during RCT.

Word List	Effect Size
1	4.58 (Small Effect)
2	1.41 (No Effect)
3	2.61 (No Effect)

Visual analysis. Visual analyses (Kratochwill et al., 2010) including the predictable baseline pattern, level, trend, variability, immediacy of the effect, degree of overlap, and consistency across phases are described in the following sections.

Predictable baseline pattern. The researcher determined the switching behavior baseline pattern through analysis of the communicative flexibility score. The participant's switching behavior did not range by more than 2 out of 10 for each word list, suggesting a stable baseline pattern.

Level. The mean communicative flexibility score for treated list one was 2.22% at baseline, 5.63% during treatment phase one, 56.02% during treatment phase two, and 25% at post-intervention. For treated list two, the mean was 10% at baseline, 9.38% during treatment phase one, 47.02% during treatment phase two, and 24.07% at post-intervention. The mean for untreated list three was 4% at baseline, 5.56% during treatment phase one, and 27.38% at post-intervention. The mean for untreated list three during treatment phase two could not be calculated because only one data point existed (i.e., 50%). The level for each of the three word lists is displayed in Figure 13.

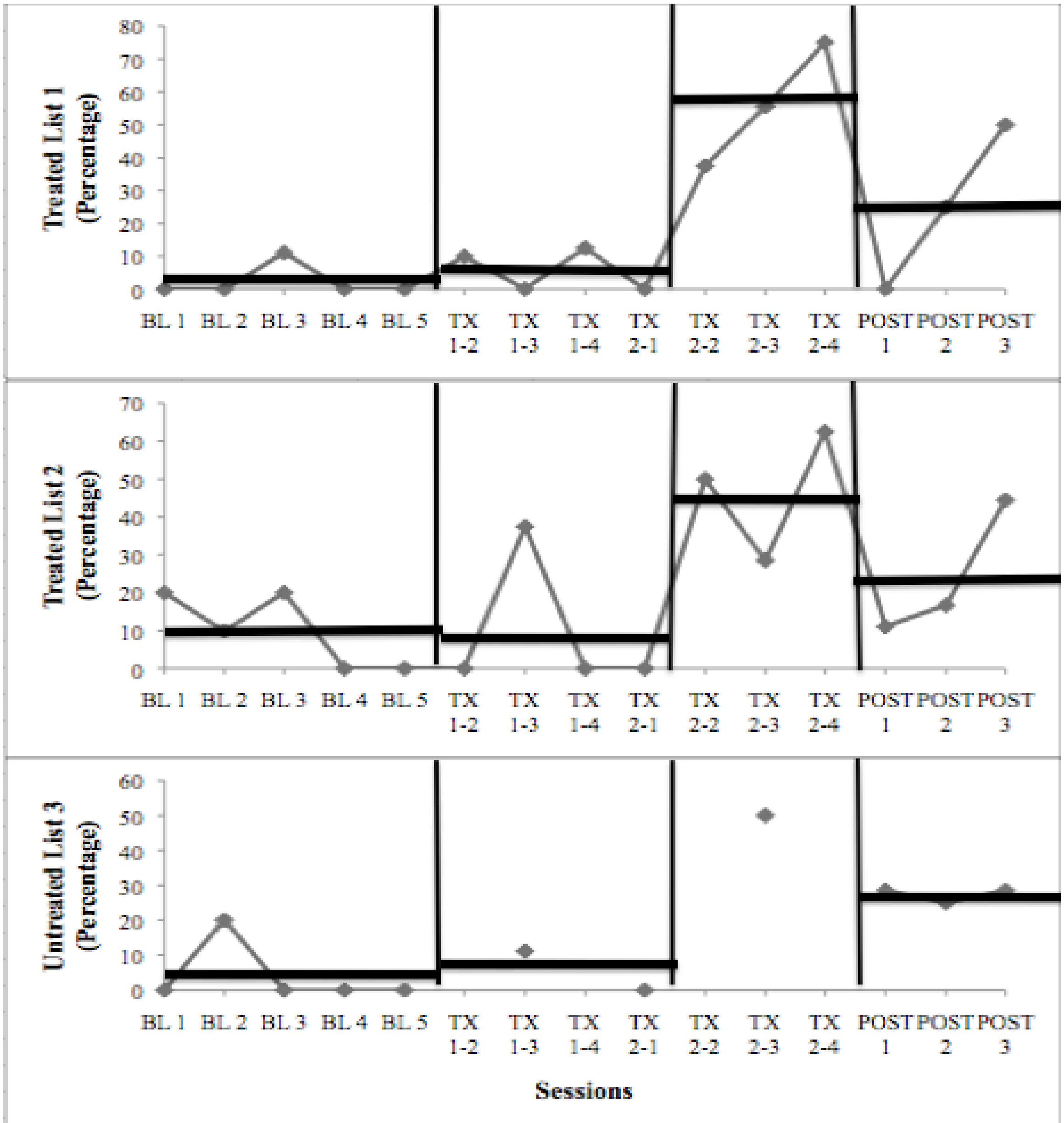

Figure 13. Visual analysis of level for the RCT communicative flexibility scores.

Trend. The trend line at baseline was zero accelerating for treated list one and decelerating for treated list two and untreated list three. During treatment phase one, the trend line was accelerating for treated list one and decelerating for treated list two. The trend line during treatment phase two was accelerating for treated list one and for treated list two. Untreated list three was probed every-other intervention session during treatment phase one and two. Therefore, the trend line for treatment phase one and two of the untreated list could not be described. The trend line at post-intervention was accelerating for treated list one and treated list two, and zero accelerating for untreated list three. The trend line for each word list is represented in Figure 14.

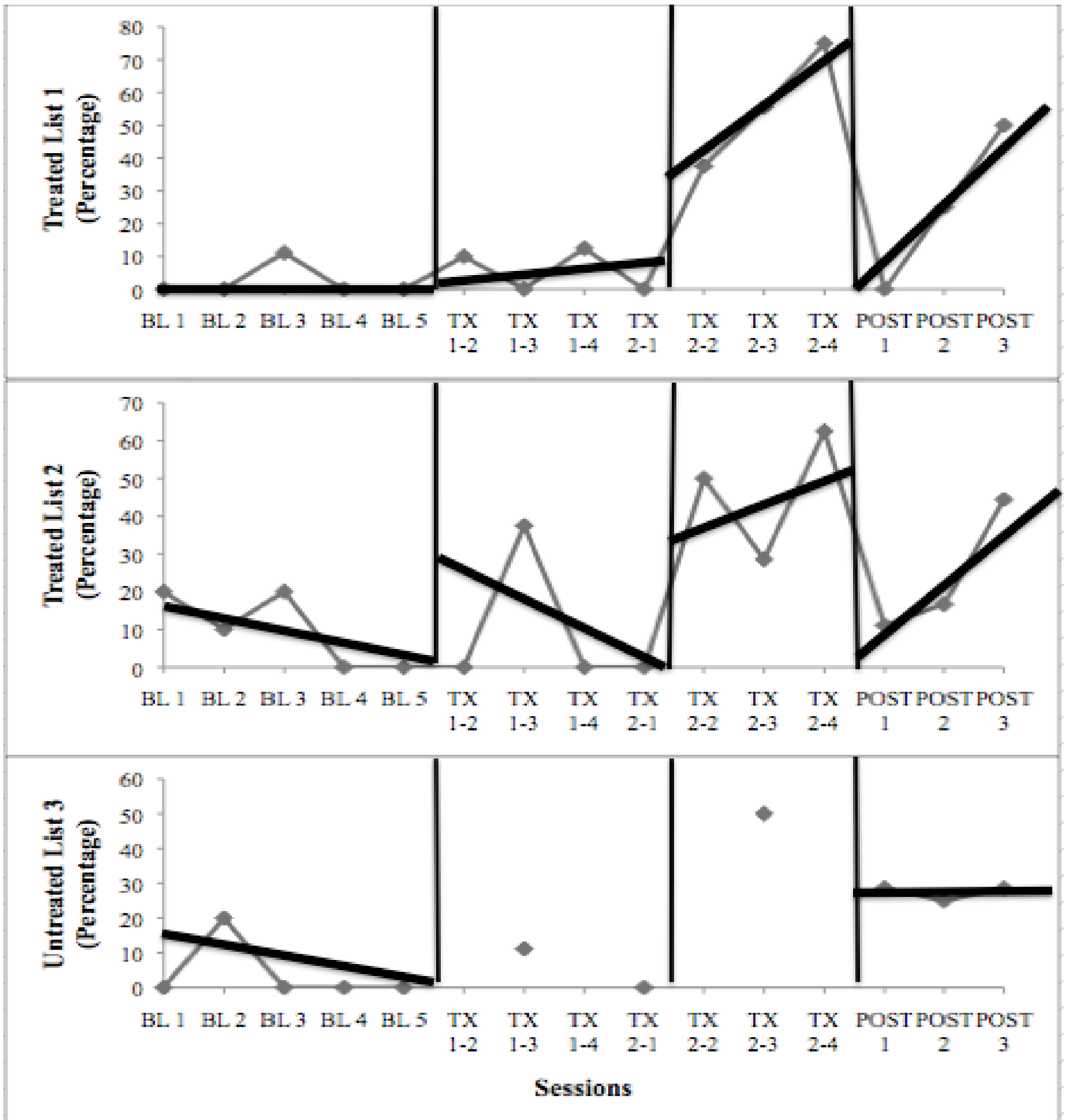

Figure 14. Visual analysis of trend for the RCT communicative flexibility scores.

Variability. At baseline, the standard deviation was 4.97% (M=2.22%) for treated list one, 10% (M=10%) for treated list two, and 8.94% (M=4%) for untreated list three. Within treatment phase one, the standard deviation was 6.57% (M=5.63%) for treated list one, 18.75% (M=9.38%) for treated list two, and 7.86% (M=5.56%) for untreated list three. During treatment phase two, standard deviation was 18.75% (M=56.02%) for treated list one and was 17.16% (M=47.02%) for treated list two. Variability could not be calculated for untreated list three because the list was only probed one time within treatment phase two. At post-intervention, the standard deviation was 25% (M=25%) for treated list one, 17.86% (24.07%) for treated list two, and 2.06% (M=27.38%) for untreated list three. Variability for the word lists is presented in Figure 15, the dotted lines depict the standard deviation and the solid lines represent the mean.

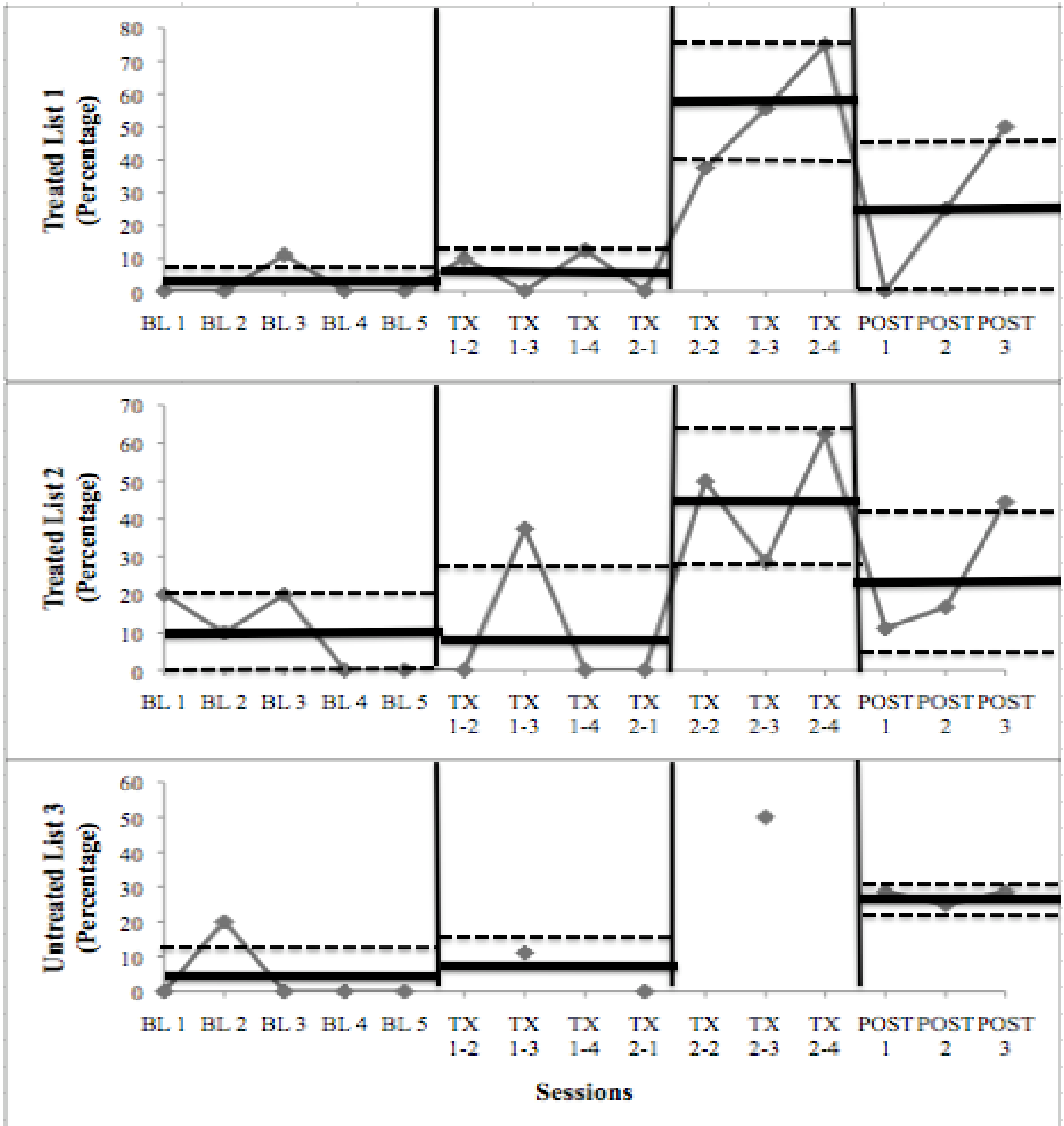

Figure 15. Visual analysis of variability for the RCT communicative flexibility scores.

Immediacy of the effect. There was no immediate effect of communicative flexibility scores between baseline and treatment phase one for treated list one and treated list two. There was an immediate effect between treatment phase one and treatment phase two for treated list one and treated list two. Between treatment phase two and post-intervention there was no immediate effect for treated list one and an immediate effect for treated list two. Immediacy of effect for untreated list three could not be determined because the word list was probed every-other intervention session. Immediacy of the effect for treated list one and treated list two is provided in Figure 16.

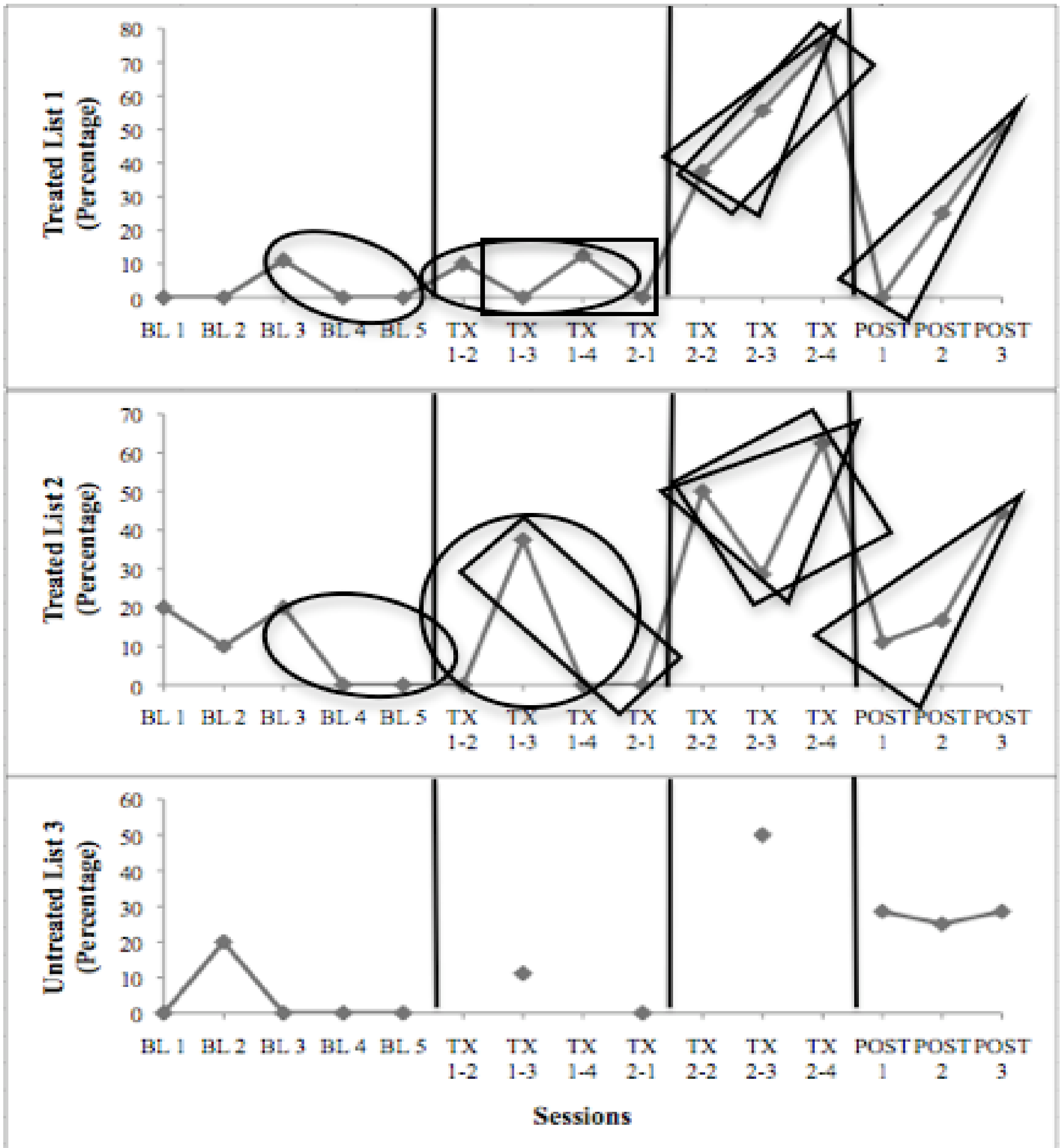

Figure 16. Visual analysis of immediacy of the effect for the RCT communicative flexibility scores.

Degree of overlap. A smaller percentage of overlapping data points was consistent with a greater effect. Between baseline and treatment phase one, treated list one had 3 overlapping data points (75%), treated list two had 3 (75%), and untreated list three had 2 (100%). Between treatment phase one and treatment phase two, treated list one had 0 overlapping data points (0%), treated list two had 1 (33.33%), and untreated list three had 0 (0%). Between treatment phase two and post-intervention, treated list one had 3 overlapping data points (100%), treated list two had 3 (100%), and untreated list three had 3 (100%). The degree of overlap for each of the three word lists is displayed in Figure 17.

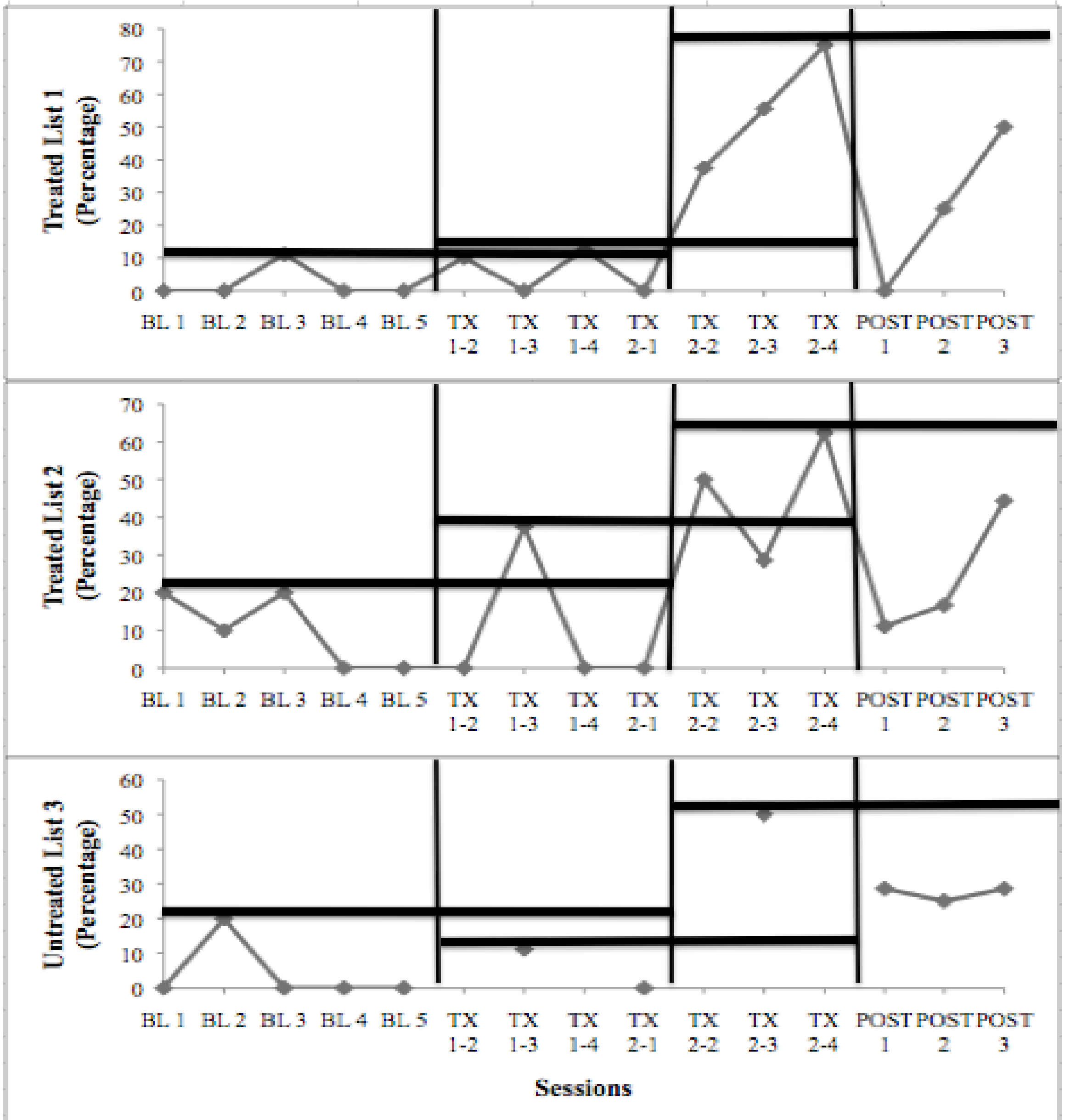

Figure 17. Visual analysis of degree of overlap for the RCT communicative flexibility scores.

Consistency of data patterns across similar phases. The data patterns between the two treatment phases indicated an inconsistent pattern of switching behavior for treated list one and treated list two. Consistency between the two treatment phases could not be determined for untreated list three, because the word list was probed every-other intervention session. The data patterns between baseline and post-intervention indicated an inconsistent pattern of switching behavior for each of the three word lists. Consistency across phases for each word list is represented by the linked ovals in Figure 18.

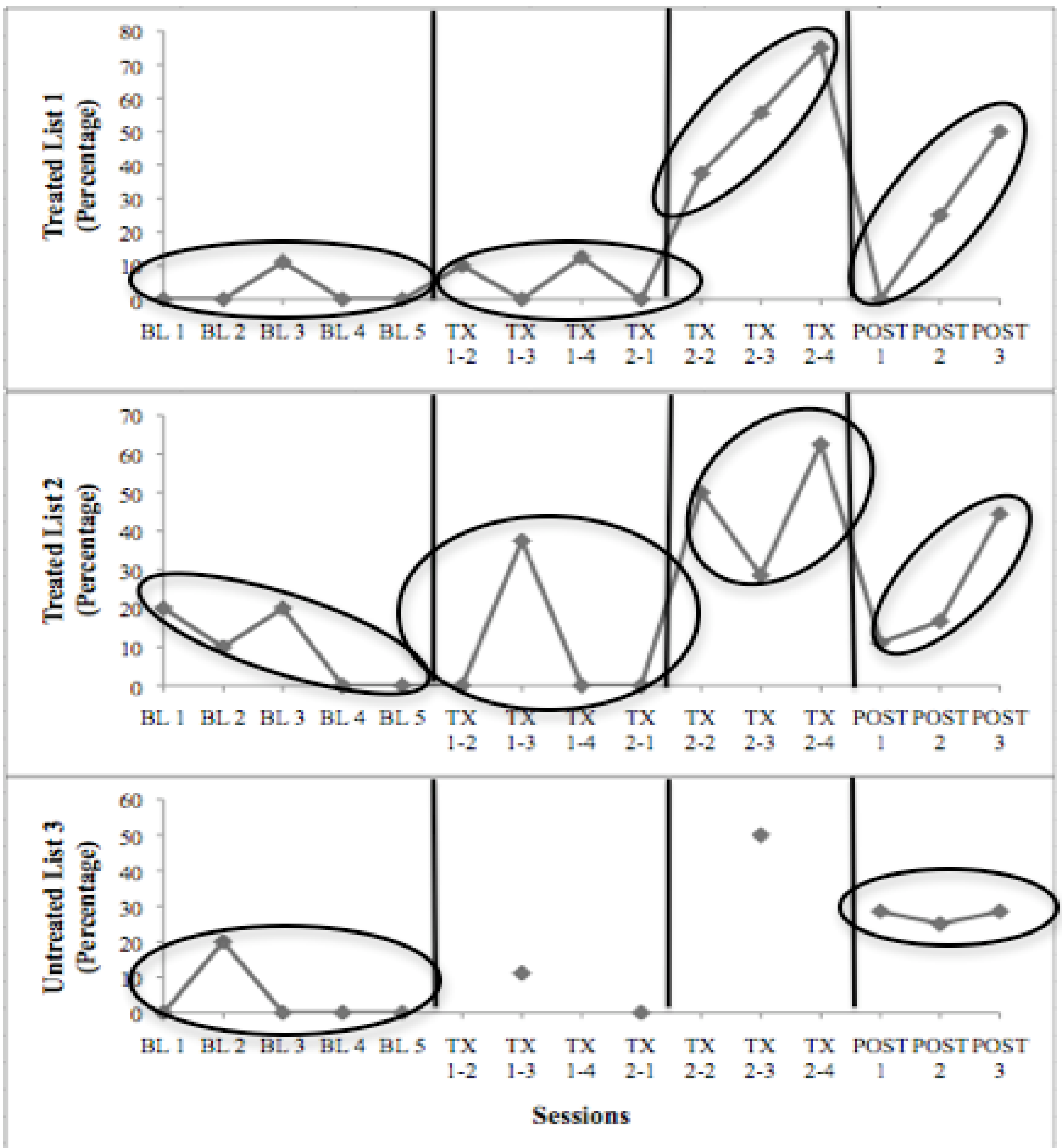

Figure 18. Visual analysis of consistency across phases for the RCT communicative flexibility scores.

Accuracy of initial modality productions. The researcher examined the effects of SFA+MCP on the participant's accuracy of initial modality productions for each word list during

RCT probes. Accurate initial modality productions were calculated out of a total of 10. The participant's frequent accurate modalities included air drawing and gesturing throughout the study, speaking during treatment phase two, and drawing during post-intervention. Overall, accuracy of initial modality productions increased during treatment phase two. The effect size for each word list was additionally calculated (Beeson & Robey, 2006). SFA+MCP resulted in no statistically significant effect size for treated list one (d=1.40), and a small statistically significant effect size for treated list two (d=4.14) and untreated list three (d=5.52). Accuracy of initial modality productions is displayed in Figure 19, and the effect size for each of the three word lists is presented in Table 9.

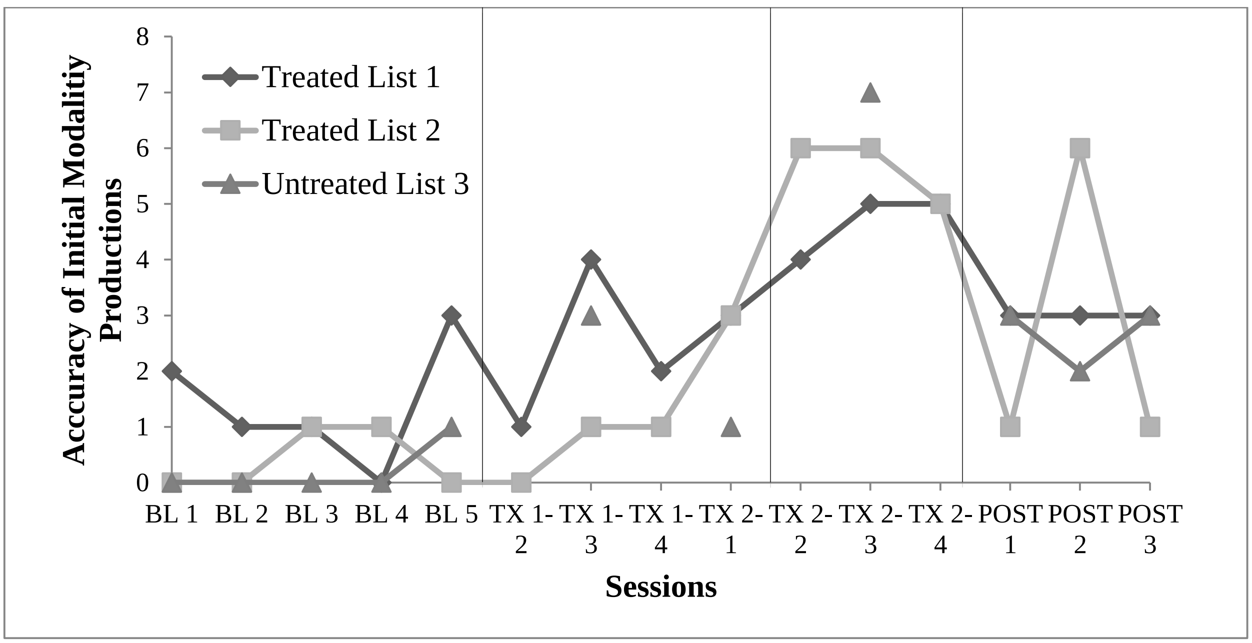

Figure 19. RCT accuracy of initial modality productions.

Table 9. Treatment effect of SFA+MCP on RCT accuracy of initial modality productions.

Word List	Effect Size
1	1.40 (No Effect)
2	4.14 (Small Effect)
3	5.52 (Small Effect)

Accuracy of second modality productions. The researcher calculated the accuracy of second modality productions (represented as a percentage) by dividing the number of accurate second modality productions by the number of second modality attempts during RCT probes. Accurate second modality productions were calculated out of a total that ranged from 4 to 10 across sessions, based on the number of opportunities to produce a second modality. Accurate modalities used by the participant included air drawing and gesturing most frequently (noted throughout the study), and speaking and drawing to a lesser degree (noted during treatment phase two). Accuracy of second modality productions increased during treatment phase two. The effect size for each of the three word lists was additionally calculated (Beeson & Robey, 2006). SFA+MCP resulted in no statistically significant effect size for treated list one (d=2.05) and treated list two (d=2.33), and a small statistically significant effect size for untreated list three (d=4.21). Accuracy of second modality productions is represented in Figure 20, and the effect size for each word list is provided in Table 10.

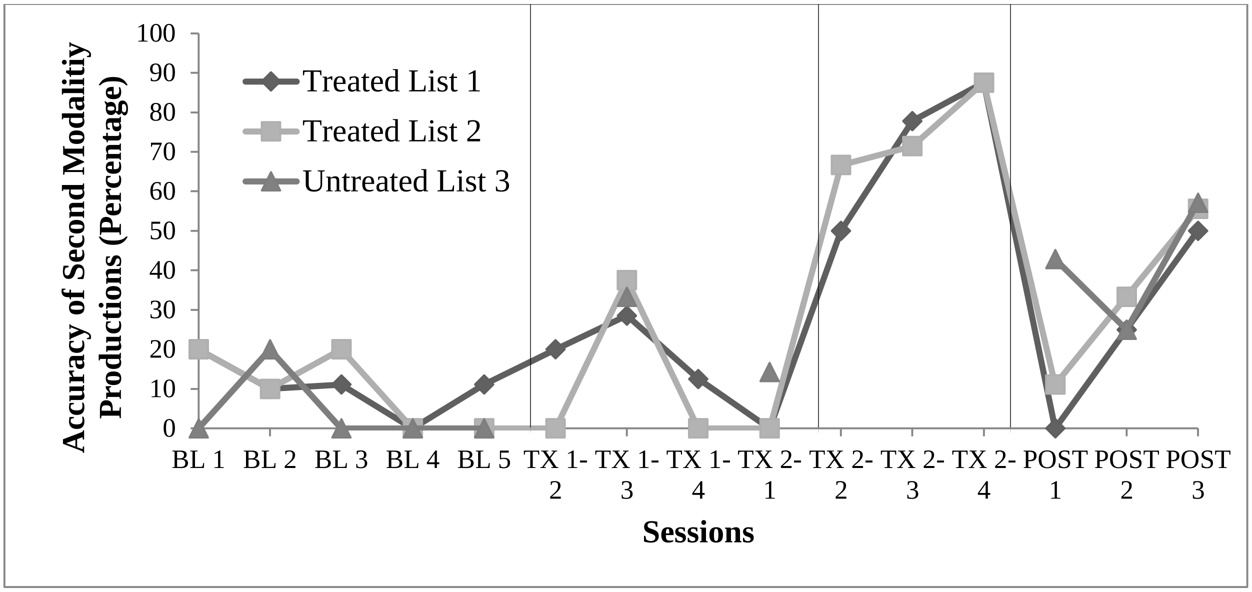

Figure 20. Accuracy of second modality productions.

Table 10. Treatment effect of SFA+MCP on RCT accuracy of second modality productions.

Word List	Effect Size
1	2.05 (No Effect)
2	2.33 (No Effect)
3	4.21 (Small Effect)

Research question three. The purpose of Research Question Three was to investigate the effects of SFA+MCP on the *CADL-2* communicative flexibility score.

Communicative flexibility score. The researcher calculated the communicative flexibility score for each of the four administrations of the *CADL-2* (three baseline administrations and one post-intervention administration) by dividing the number of modality switches by the number of opportunities to switch. The *CADL-2* communicative flexibility score was 0 across the four administrations, indicating no switching behavior changes as a result of SFA+MCP.

Research question four. The purpose of Research Question Four was to examine 11 naïve listeners' accuracy of identifying the participant's communication attempts at baseline and post-intervention. The graph of individual responses indicated each listener demonstrated increased identification accuracy during post-intervention probes compared to baseline probes. The listeners' individual responses are displayed in Figure 21. A t-test analysis revealed a greater listeners' accuracy score during post-intervention RCT probes compared to baseline RCT probes ($p < 0.00$).

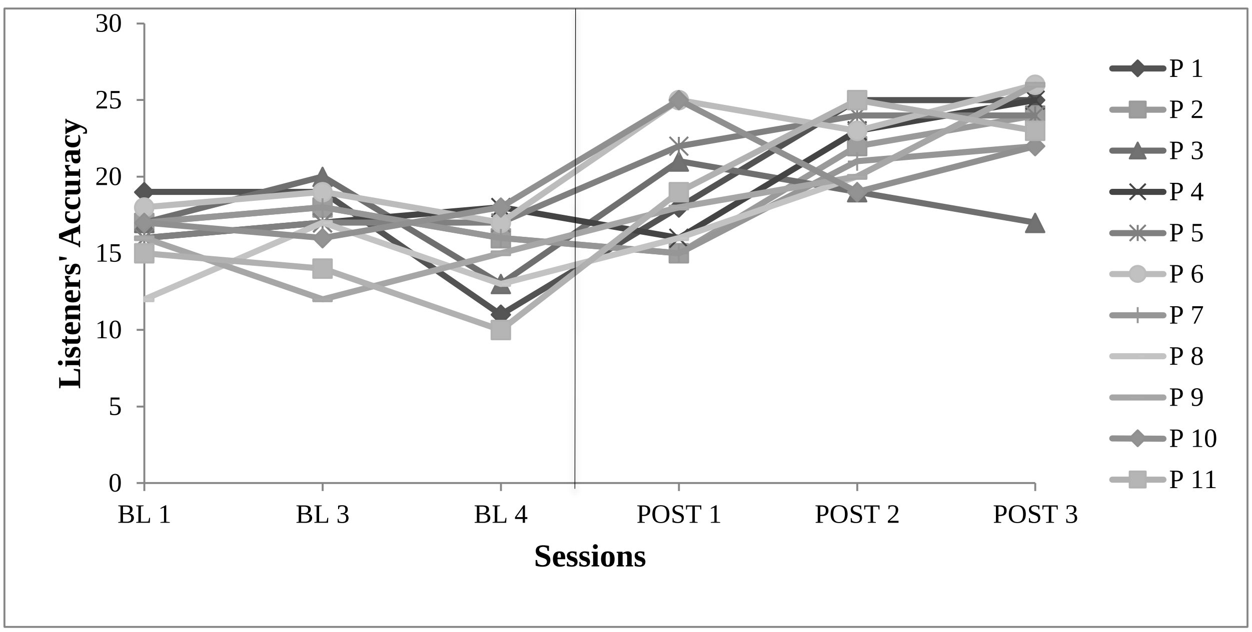

Figure 21. Listeners' accuracy of participant's communication attempts.

Results of Formal Assessments

The participant's *WAB-R* AQ increased by 5.9 points between baseline and post-intervention. She received the highest score on the *CADL-2* with standard scoring during post-intervention compared to baseline. The participant's raw scores on *PALPA* Subtests 48 and 52 did not change between baseline and post-intervention, whereas Subtest 51 increased by 1 out of

15 points. Overall, the participant's *CLQT* Subtests scores remained the same or increased between baseline and post-intervention. The *CLQT* Design Memory Subtest served as the baseline control measure, and was predicted to remain stable following intervention. However, the participant's Design Memory Subtest score increased by 3 out of 6 points. The participant's score on the *WCST* decreased by 16 out of 128 points following treatment. Baseline and post-intervention formal assessment scores are provided in Table 11.

Table 11. Baseline and post-intervention formal assessment scores.

Formal Assessments	Baseline	Post-Intervention
Western Aphasia Battery-Revised (Aphasia Quotient)	61.4	67.3
Communicative Activities of Daily Living-2	61/100	67/100
Psycholinguistic Assessment of Language Processing in Aphasia		
Subtest 48: Written Word-Picture Matching	39/40	39/40
Subtest 51: Word Semantic Association	11/15	12/15
Subtest 52: Spoken Word-Written Word Matching	15/15	15/15
Cognitive Linguistic Quick Test		
Symbol Cancellation	0/12	3/12
Clock Drawing	7/13	8/13
Symbol Trails	10/10	10/10
Generative Naming	1/9	1/9
Design Memory	2/6	5/6
Mazes	0/8	0/8
Design Generation	2/13	5/13
Wisconsin Card Sorting Test	81/128	65/128

[a] Communicative Activities of Daily Living-2 baseline score was an average of three test scores.

CHAPTER IV

Discussion

The current study examined the effects of SFA+MCP on word retrieval and switching behavior in a person with PPA. The accuracy with which naïve listeners identified the participant's baseline and post-intervention communication attempts was also investigated. SFA+MCP was predicted to increase the participant's naming accuracy (i.e., word retrieval) by strengthening activation within the semantic network, and to reduce communication breakdowns by increasing the automaticity of switching between modalities. Because word retrieval and switching were believed to improve following SFA+MCP, the naïve listeners' identification of the participant's communication attempts was also predicted to increase following intervention.

Overall, results of the study were mixed, but generally showed minimal changes in word retrieval accuracy and switching following SFA+MCP. However, increased RCT communication modality productions were noted. Furthermore, results of the listener task suggested that SFA+MCP may have improved the participant's communicative effectiveness in a way that was not captured by other measures (i.e., word retrieval accuracy and switching).

The researcher investigated possible explanations for the unexpected results of the study. These explanations are described relative to the participant's word retrieval, modality use, and switching, as well as in the context of the listener task. Additionally, formal assessment results and participant performance factors are explained. Finally, study limitations and future research are discussed.

Word Retrieval

SFA+MCP was hypothesized to improve the participant's naming accuracy particularly when implemented at a high intensity. Results of the Confrontation Naming Task (CNT) probe analysis indicated no statistically significant treatment effects for the participant's word retrieval accuracy. A number of factors may have contributed to the lack of significant treatment effects. First, although naming improvements were not noted, the participant's word retrieval accuracy score was maintained throughout the study. That is, the participant's performance did not decrease from baseline to post-intervention. Given the neurodegenerative nature of PPA, a decrease in the participant's naming abilities may have been expected, even during the study's 7-week period. Estimations of expected declines in the participant's performance were difficult to determine due to the lack of research about the rate of communication decline in people with PPA. One report indicates that language skills decreased across a short time frame, such as 2 months (Riesthal, 2011). As a result, it is possible that in the current study, SFA+MCP helped maintain the participant's word retrieval skills.

Second, based on the formally tested and informally observed cognitive deficits (e.g., memory and executive functions), the researcher observed that the participant had likely progressed beyond the early stages of PPA (King et al., 2007). In the early stages of PPA, SFA+MCP was thought to improve spoken expression. However, the participant's linguistic abilities may not have been able to be restored to the same degree as reported in other studies because in the later stages moderate to severe language and cognitive impairments would be expected (Henry et al., 2008).

Although changes in word retrieval did not occur, other changes in the participant's language productions were noted. Due to the participant's word retrieval deficit, circumlocution of target concepts frequently occurred. At the beginning of the study, the participant's circumlocutions consisted of vague and general semantic features. For example, the participant verbally described both a *bird* and a *cat* as "creatures", without providing other semantic features. As the study progressed, circumlocution was still noted, however verbal descriptions of the targets appeared to contain more specific semantic features. For example, the participant verbally described *glasses* as “if you are having a hard time seeing things, they will help you see everything better”. Although word retrieval did not improve following intervention, the effects of SFA+MCP may explain the participant’s increased use of specific semantic features to support communicative effectiveness.

Non-Verbal Modality Use during the Confrontation Naming Task

During CNT probes, the researcher noted the participant’s unexpected use of non-verbal communication modalities that accompanied word retrieval. During the CNT the researcher instructed the participant to name the target concept, and made no mention of the use of alternative communication modalities. While the use of correct non-verbal communication modalities did not statistically improve (i.e., no significant effect sizes) following SFA+MCP, the participant maintained the use of alternative communication modalities during word retrieval throughout the study. The participant was more accurate in production of non-verbal modalities (i.e., air drawing and gesturing) compared to verbal expression (i.e., naming) of concepts during baseline and post-intervention confrontation naming tasks.

Furthermore, the participant may have used non-verbal communication modalities during CNT probes to self-cue her verbal expression of the concept (Ferguson, Evans, & Raymer, 2012). For example, gesturing the concept *broom* may have led to verbal expression of *broom*. Additionally, similar to previous studies, the participant produced communication modalities in combination (Carr & Wallace, 2004). That is, the participant verbally described *broom* while she gestured *broom*. The participant’s maintained use of alternative communication modalities and increased use of combined modalities may be explained by implementation of MCP. The non-verbal modalities (e.g., gesturing, and drawing) taught during MCP may have generalized to CNT probes. In addition to this unexpected finding (i.e., alternative communication modality productions during confrontation naming tasks), modality use was measured during other tasks as described in the next section.

Switching

SFA+MCP was hypothesized to increase the automaticity of switching among modalities to repair communication breakdowns, and to increase the use of alternative modalities. For the most part, results of the Referential Communication Task (RCT) and *CADL-2* switching analyses indicated that SFA+MCP did not have significant effects on the participant's switching. However, RCT switching visual analyses results (e.g., level) suggested improvement in the participant's performance following intervention. Therefore, although significant changes did not occur, subtle switching improvements were noted following SFA+MCP. A number of factors may explain why the participant's switching was relatively unchanged following SFA+MCP.

First, the participant may have been confused about the RCT instructions. This was evident in the manner the participant completed RCT probes. For example, the participant occasionally made statements such as, "I am going to make it easy for you this time, I'm just going to say what it (the concept) is". Additionally, the participant inconsistently followed the RCT directions, as if she forgot the task instructions and required reminders of the purpose of the task throughout its completion. This was particularly evident as the participant's switching performance improved during treatment phase two, when the researcher slightly modified the RCT to provide the participant with reminders of the instructions throughout the task.

Second, the structured nature of the RCT may have contributed to the participant's decreased understanding of the task. The task may have been too structured, and not representative of natural communicative situations, leading to the participant's decreased comprehension of the task. For example, the participant may not have consistently recognized that when the communication partner presented a non-target line drawing it was indicative of a communication breakdown, and therefore did not switch modalities. However, the structured nature of the RCT was needed to explicitly measure the participant's switching and to maintain experimental control. When the RCT was altered during treatment phase two to improve the participant's comprehension and to introduce some elements of a natural communicative environment, the participant's communicative flexibility score (i.e., switching) increased. During post-intervention, the researcher re-introduced the original RCT, and the participant's communicative flexibility scores decreased, signifying the participant's poor understanding of the RCT instructions and the effects of a structured task.

Third, as previously mentioned, during the course of the study it became evident that the participant may no longer have been in the early stages of PPA. Although MCP was thought to address some cognitive impairments such as executive functions deficits (i.e., cognitive flexibility), MCP may not have had the intended effects because of the greater than expected impairments in other cognitive domains (i.e., memory). Reduced memory abilities may have resulted in the participant's difficulty learning new information, such as the use of alternative modalities to repair communication breakdowns. If SFA+MCP was introduced during the early stages of PPA, the participant's cognitive abilities may have better supported new learning, and greater benefit from SFA+MCP may have been achieved.

Finally, the *CADL-2* served as an additional measure of the participant's switching. Results indicated that the participant did not switch modalities during the four administrations of the assessment. Similar to the RCT, the participant may not have been able to identify when a communication breakdown occurred, and when a modality switch was necessary. The participant's memory of alternative communication modalities, or their use in functional communicative situations, may have also resulted in her lack of switching throughout the four administrations of the *CADL-2*.

Switching and Alternative Communication Modality Use

The participant's accuracy of alternative modality productions was measured across first and second attempts during RCT probes, and small effect sizes were noted. Small initial modality treatment effects were calculated for treated list two and untreated list three, and small second modality treatment effects were computed for untreated list three. The treatment effects of untreated list three suggest that the strategies (i.e., use of alternative modalities) taught during MCP generalized to untreated words. Similar to previous studies, although SFA+MCP did not significantly improve the participant's switching, MCP resulted in increased use of accurate communication modalities, specifically air drawing, gesturing, and drawing (Wallace et al., *in press*). While gesturing and air drawing were noted throughout the study, the participant began to use drawing during treatment phase two and post-intervention. Therefore, MCP may have provided the participant with an additional communication modality to use to support her communication.

The participant's use of alternative communication modalities notably improved during treatment phase two of the study. This may be explained by the altered RCT (described above). Following review of task instructions, the participant was more likely to use non-verbal modalities. The participant's memory impairments may have resulted in the inability to recall the task instructions during the RCT, explaining why reiteration of the instructions resulted in increased accuracy of communication modalities during treatment phase two. Similar to the communicative flexibility score, accuracy of first and second modality productions decreased during post-intervention probes when the original RCT was re-introduced.

Perceived Communicative Effectiveness

Although changes in word retrieval accuracy and switching were limited, results of the listener task indicated that SFA+MCP resulted in the participant's increased communicative effectiveness. That is, small changes in alternative modality productions combined with potentially more specific circumlocutions helped listeners' better identify the participant's productions following SFA+MCP. Overall the naïve listener task captured what the other tasks of the study did not obtain, the participant's improved communicative effectiveness following SFA+MCP. This finding highlights the need to develop better methods to capture outcomes of treatments like SFA+MCP (Tompkins et al., 2006).

Formal Assessments

The majority of formal assessment scores improved slightly or remained the same from baseline to post-intervention, suggesting minimal effects of SFA+MCP on the participant's performance during formal assessments. The *WAB-R* AQ and the *CADL-2* raw scores improved the most following SFA+MCP. Improvements on the *WAB-R* AQ and *CADL-2* may have been due to the combined linguistic and cognitive components of SFA+MCP. Similar to the listener task, the *CADL-2* may have captured what the experimental tasks did not, the participant's improved communicative effectiveness following SFA+MCP. However, due to generally unchanged word retrieval and switching following SFA+MCP, improved *WAB-R* and *CADL-2* scores may also be explained by the participant's performance variability. Additionally, the participant's increased *CADL-2* score may reflect learning due to repeated administrations (i.e., three baseline administrations). However, this explanation is unlikely due to the participant's observed memory impairment.

Although the participant's *WCST* scores decreased from baseline to post-intervention, her performance on other measures of cognitive flexibility (e.g., *CLQT* Subtests or RCT probes) did not decrease. No changes reported by the participant or her husband would suggest that the participant had a meaningful decline in executive functions during the course of the study. A possible explanation for these results is that the *WCST* was more sensitive than other measures to her variable performance across sessions.

Participant Performance Factors

The participant's performance across study tasks was likely impacted by fatigue, decreased processing speed, and limited deficit awareness. These three factors may have affected the results of the study and should be taken into consideration in the design of future interventions and studies for people with PPA.

The participant's performance during CNT probes and RCT probes was variable. Although she often performed within a small range of accuracy, her performance would decrease unexpectedly at times. For example during treatment phase one, the participant's communicative flexibility score decreased from 37.5% to 0% from one treatment session to the next. The participant's fatigue during everyday tasks (as reported by her husband) may have increased the impact of her cognitive impairments on days of the study, resulting in a drop in performance on study tasks. Fatigue in the current study was a particular concern because of the intense nature of the study protocol (i.e., daily sessions, which included probe and treatment tasks, lasting 3 to 4 hours each) (Tanaka, Shigihara, Funakura, Kanai, Watanabe, 2012). This occasional drop in performance highlighted the need to carefully track the participant's performance across multiple probes in the study. Additionally, these drops in performance made it difficult to evaluate the benefit the participant may have received from this intervention.

The participant also required greater than anticipated time to complete study tasks (e.g., formal assessments, CNT, RCT, and intervention). For example during CNT probes, the participant occasionally accurately named the target word following the 15-second time limit (i.e., after 40 seconds), therefore affecting the word retrieval accuracy score. This is believed to be due to the participant's cognitive and language deficits resulting in slowed processing speed across tasks. As some of the formal assessment tasks were timed (e.g., a number of *CLQT* Subtests), these scores were also reduced.

Finally, the participant may have had limited deficit awareness which may have affected her performance during the study. If the participant did not fully understand the impact of her impairments, she may not have found the need to implement intervention strategies during experimental tasks. For example during the RCT, the participant may not have been aware that her cognitive and communication deficits led to communication breakdowns, and therefore did not fix the breakdown by switching to an alternative modality. Furthermore, the *BOSS* confirmed the participant's reduced impairment awareness. While the participant identified difficulty with word retrieval, she had decreased awareness of other deficits (e.g., communicating with a group of people). These responses contrasted with her performance during experimental tasks and with her husband's identified areas of difficulty. In particular, the participant's husband may have more accurately identified the emotional affects of her communication impairment.

Limitations and Future Research

Results of this study provided information about the effects of SFA+MCP on word retrieval and switching behavior in a person with PPA. The outcomes of this study are based on a single participant, therefore the generalization of the effects of SFA+MCP to additional people with PPA are limited. However, consideration of this study's results may be useful when designing future intervention programs for people with PPA. Based on the results of this single-participant design, studies with an increased number of participants and with modifications to SFA+MCP are warranted. Specifically, the participant's increased modality productions and the improved listeners' accuracy score indicate the need for future studies.

Another limitation relates to the researcher's decision to modify the RCT during treatment phase two, as this resulted in difficulty comparing the RCT during this phase to other study phases. However, the modifications provided information about the participant's poor understanding and memory of the referential communication task. This information may be considered when planning future studies, specifically when designing functional measures of switching behavior.

While an intensive intervention was planned, accommodations that the researcher believed necessary, due to the participant's fatigue, decreased the number and frequency of sessions. The participant did not attend one treatment session during each treatment phase. As a result, the participant completed a total of eight treatment sessions, instead of the intended 10 treatment sessions. Due to the participant's reduced attendance, some visual analyses for untreated list three, during treatment phase one and two, could not be completed. Additionally, due to the participant's fatigue, a 1-week break was given between treatment phase one and treatment phase two, once again reducing the intensity of the intervention. As previously mentioned, the participant did not complete the SFA homework as intended, further reducing the intensity of the intervention. Future studies should investigate the appropriate dosage (i.e., intensity) of treatment as well as approaches to accommodate issues such as fatigue.

This study was designed for a person in the early stages of PPA. The participant's unexpected cognitive impairments (e.g., memory) may have decreased the effects of the study. However, the participant's cognitive impairments provide guidance for future research. That is, researchers should consider the cognitive deficits of people with PPA, and make modifications to intervention to aid these impairments. For example, incorporating memory strategies (e.g., errorless learning, spaced retrieval) in treatment of switching behavior may reduce the demands on the participant, and may facilitate successful learning of communication modalities. Researchers may also investigate comprehensive staging of PPA (i.e., further than early, middle, and late stage), and the most appropriate treatment for these stages.

Additional future research should examine interventions like SFA+MCP combined with provision of education to caregivers of people with PPA. Researchers may teach caregivers the effective communication strategies for people with PPA. For example, teaching caregivers to use multiple input modalities (e.g., gesturing, drawing, and writing key words) to increase comprehension (Riesthal, 2011). Teaching partners strategies has been found to be a successful treatment approach for people with stroke-induced aphasia, but limited research has examined similar approaches in PPA (Kagan, Black, Duchan, Simmons-Mackie, & Square, 2001). Relative to the current study, training the communication partner simultaneously with SFA+MCP might have provided the participant with increased practice and resulted in generalization of skills, while better managing fatigue.

Conclusion

The primary aim of this study was to examine the effects of SFA+MCP on communicative effectiveness in a person with PPA. The results provide valuable information regarding the design and implementation of semantic and multimodal interventions for people with PPA. Despite mixed results, the participant showed some improvements in communicative effectiveness (i.e., listeners' accuracy and participant's correct modality productions increased) following SFA+MCP. Further investigations of these treatments, specifically relative to timing and intensity, as well as the appropriate modifications for people with cognitive impairments associated with PPA are warranted.

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Appendix 1. Recruitment flyer.

Primary Progressive Aphasia Research Study

Purpose: This study will evaluate a multimodality treatment for primary progressive aphasia.

To participate, you must:

- Have a diagnosis of primary progressive aphasia within the last 2 years
- Be between 18-85 years old
- Speak American English
- Have normal hearing and vision (glasses or contacts are okay)
- Not be enrolled in individual speech therapy during the study

Time required:

- 18 sessions lasting between 2 and 3.5 hours each
- 4 optional sessions lasting about 2 hours each

Study Activities:

- Answering questions, describing pictures, following directions, repeating words, moving objects, etc.
- Practice speaking, gesturing, drawing, and pointing in a communication notebook to communicate key words
- Practicing communicating with a partner

Location:

- Sessions can take place at Duquesne University or your home.

You will not be paid for your participation

If you are interested, please contact

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Appendix 2. Listener task stimuli.

Ball	Kite
Bat	Knife
Bicycle	Magazine
Bird	Nail
Book	Necklace
Bowl	Padlock
Bracelet	Paper
Broom	Pen
Bucket	Pencil
Butterfly	Phone
Camera	Photograph
Car	Piano
Cat	Plate
Chair	Ring
Clock	Saw
Computer	Saxophone
Contacts	Scissors
Cup	Screwdriver
Dog	Shirt
Door	Spoon
Drum	Table
Earrings	Tennis Racquet
Flute	Tie
Fork	Toothbrush
Glasses	Toothpaste
Gloves	Trombone
Guitar	Trumpet
Hammer	Violin
Hat	Watch

Key	Window

1) ____

2) ____

3) ____

4) ____

5) ____

6) ____

7) ____

8) ____

9) ____

10) ____

11) ____

12) ____

13) ____

14) ____

15) ____

16) ____

17) ____

18) ____

19) ____

20) ____

21) ____

22) ____

23) ____

24) ____

25) ____

26) ____

27) ____

28) ____

29) ____

30) ____