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Comparing the treatment effect of conversational and traditional aphasia treatments on linguistic complexity measures

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COMPARING THE TREATMENT EFFECT OF CONVERSATIONAL AND
TRADITIONAL APHASIA TREATMENTS ON LINGUISTIC COMPLEXITY MEASURES

A Thesis

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

in

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by
Kelsey Ann Copperberg
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ABSTRACT

Linguistic complexity is frequently analyzed in studies of child language acquisition and impairment (Heilmann, Miller, & Nockerts, 2010; Price, Hendricks, & Cook, 2010) and the language of aging adults (Capilouto, Wright, & Wagovich, 2005; Kemper & Sumner, 2001; Kemper, Thompson, & Marquis, 2001; Kynette & Kemper, 1986; Shewan & Henderson, 1988) to document changes over time. There is little, if any, literature applying linguistic measures to analyze the language of individuals with aphasia as well as to analyze effects of different treatment measures. The current study analyzed semantic and syntactic components of linguistic complexity used by people with aphasia (PWA) during conversation probes to determine whether conversation therapy (Ctx) results in greater linguistic complexity than traditional stimulation therapy (Ttx).

Two cases were taken from a prospective, single subject, $A_1B_1A_2B_2A_3$ treatment study replicated across four individuals with aphasia (Savage et al., 2013). The language transcripts of two participants (P1 and P4), who received both Ctx and Ttx, were analyzed using Systematic Analysis of Language Transcripts (SALT; Miller & Iglesias, 2010) for six linguistic complexity measures: mean length of utterance (MLU), number of different words (NDW), type-token ratio (TTR), percent of utterances, percent of simple, and percent of complex utterances. These measures were compared between the treatments.

Data analyses were conducted using effect size calculations and visual inspection. Results indicated that 4 of the 6 measures (MLU, TTR, % utterances, % complex utterances) showed greater gains in linguistic complexity following Ttx than Ctx. However, neither participant maintained gains once treatment was removed. This study provides preliminary evidence that

linguistic complexity measures may provide useful treatment outcome measures for researchers and clinicians interested in treating PWA.

LITERATURE REVIEW

AGING POPULATION

In the United States, there are 40.4 million individuals aged 65 years and older, a number expected to nearly double to 72.1 million in 2030 (Administration on Aging, 2011). Chronic illnesses, injuries, and disabilities affect the older adult population (Center for Disease Control and Prevention, 2007, p. III). With the rise in the aging population, the risk of stroke is more prevalent since stroke risk doubles after the age of 55 (Stroke Center, 2012). Approximately 795,000 strokes occur each year, and are a leading cause of long-term disability in adults (National Stroke Association, 2012). The neurogenic damage caused by strokes may result in communication disorders, specifically of concern to this study, the aphasias.

The aphasias are language disorders resulting from damage to the language dominant (typically left) hemisphere (Kean, 1977) and are most commonly seen in adults who have had a stroke (National Institute of Neurological Disorders and Stroke, 2010). Approximately 80,000 individuals acquire aphasia from strokes each year, and about 1,000,000 people in the United States live with aphasia (NIDCD, 2010). Aphasia is a chronic disorder with lasting effects that significantly impact the daily lives of those with the disorder and their families (Simmons-Mackie, 2008). Aphasia can have a negative impact on social life, identity, and overall quality of life (Fox, Armstrong, & Boles, 2009). Many of the lasting effects that impact quality of life are results of linguistic impairments. Before speech-language pathologists (SLPs) assess individuals with aphasia they should have an understanding of the changes that result from the normal aging process in order to differentiate abnormal linguistic changes from normal linguistic changes.

CHANGES IN LINGUISTIC COMPLEXITY DUE TO AGING

Speech-language pathologists treat many older individuals with communication disorders. To treat the aging population effectively, SLPs require knowledge of the differences between communication changes that may be due to aging and those due to disease or disorder that result in communication deficits. This knowledge is critical for differentiating behaviors related to aging from symptoms of communication disorders (Shewan & Henderson, 1988; Yorkston, Bourgeois, & Baylor, 2010).

Various researchers have investigated age-related changes of language and linguistic complexity (Burke & Shafto, 2008, Kemper, Herman, & Lian 2003, Kemper & Sumner, 2001; Kemper, Thompson, & Marquis, 2001; Shewan & Henderson, 1988; Verhaeghan, 2003). Results reveal that in general, communication abilities are well preserved in the normally aging population. “Basic linguistic abilities (grammar and concept formulation) were not grossly impaired in aging” (Shewan & Henderson, 1988, p. 139). Shewan and Henderson investigated the effect of aging on language. The researchers recruited 60 adults with no neurological deficits or communication disorders to form four groups, one for each decade between the ages of 40-79 years. Language samples of picture descriptions were audio-recorded for each participant. The investigators transcribed and analyzed each sample using the *Shewan Spontaneous Language Analysis* (SSLA) system (Shewan, 1988). Variables for analysis included number of utterances, time (total speaking time in minutes), rate (syllables per minute), length (percent of utterances \leq 5 words), melody, articulation, complex sentences (percent of utterances that contained one independent clause and one or more dependent clauses), errors (percent of grammatical, syntactic, or morphological errors), content units (units that conveyed information), paraphasias (percent of substitutions), repetitions, and communication efficiency (content units/time).

Consistent age-related declines were not noted. The authors did not find any statistically significant differences between age groups on any of the measures except communication efficiency, as measured by content units communicated over time, and number of substitutions in spontaneous speech. The youngest group (40-50) demonstrated better communication efficiency than the older age groups; as age increased, the participants talked longer but their content units remained the same. The oldest age group (70-79) produced the most substitutions in spontaneous speech.

This study shows that overall expressive language remains relatively stable as people age, with the exception of the number of substitutions in spontaneous speech and time needed to communicate. Thus, frank deficits in expressive language ability beyond those described above may not be considered part of normal declines in language due to the aging process.

As mentioned above, researchers have reported that expressive language is relatively spared, with the exception that declines in complex syntax production have been reported (Burke & Shafto, 2008). Kemper, Herman, and Lian (2003) investigated sentence production in older and younger adults using two experiments. In experiment one, 30 young adults (18-28 years of age) and 30 older adults (70-80 years of age) participated. The researchers presented the participants with words and asked them to use the words in a sentence as quickly as possible. Each participant completed 36 two-word, 36 three-word, and 36 four-word combinations. Researchers compared task completion time. The older adults' responses were shorter, less complex, and contained less information than the young adults' responses. This study shows that, as a result of aging, the production of complex syntax is reduced.

In experiment two, the researchers investigated the effect of verb choice on sentence production. Thirty young adults (18-28 years of age) and 30 older adults (70-80 years of age)

participated. The study included three types of verbs: simple intransitive verbs (such as “smiled”), transitive verbs (such as “called”), and complement-taking verbs (such as “wished”). The researchers presented the words to the participants as an agent and a verb. Each participant completed 18 two-word combinations with all three verb types and 18 agent-locative-verb combinations with all three verb types. Older adults were more nonfluent and made more errors, especially for complement-taking verbs (such as wished), than younger adults. The results demonstrated that older adults produced shorter and simpler sentences, which reduced the overall syntactic complexity of their sentences (Kemper, Herman, & Lian, 2003).

Although most expressive language abilities remain fairly stable during aging, both of these experiments by Kemper, Herman, and Lian (2003) support the claim that complex syntax production declines with age. Although syntax production of individuals with aphasia is usually more impaired than that seen in normal aging individuals, it is important for clinicians to know that syntax production declines with age to be able to separate language changes due to normal aging and those that signify a language disorder such as aphasia.

Many authors report that vocabulary increases throughout adulthood but declines in late adulthood (Burke & Shafto, 2008; Kemper, Thompson, & Marquis, 2001; Kemper & Sumner, 2001; Verhaeghan, 2003), particularly after age 70 years (Lindenberger & Baltes, 1997). Kemper, Marquis, and Thompson (2001) examined linguistic changes in healthy older adults using a longitudinal design. Thirty older adults, aged 65 to 75 years at the study’s initiation, participated. Each participant provided oral language samples and completed the *Mini Mental Status Examination* (MMSE; Folstein, Folstein, & McHugh, 1975) and Digits Forward and Digits Backward subtests from the *Wechsler Adult Intelligence Scale—Revised* (WAIS-R; Wechsler, 1981) vocabulary test every year for 15 years. The investigators found that

grammatical complexity, digit span scores, and vocabulary declined across the 15 years. In particular, investigators noted that the mid-70s participants exhibited a period of rapid decline followed by gradual decline. This study shows that both vocabulary and grammatical complexity decline due to the normal aging process. Clinicians should know that vocabulary declines around the age of 75 as a result of normal aging, showing a period of rapid decline followed by a gradual decline. Significant declines in vocabulary before this age may indicate a language disorder.

Normal aging results in declines in syntactic complexity and vocabulary, but other aspects of language expression remain intact (correct grammar use, articulation, communicated information, and pragmatic use of language). This knowledge is important in differentiating normal declines in linguistic complexity from impairments resulting from communication disorders such as the aphasias which will be discussed next.

CHANGES IN LINGUISTIC COMPLEXITY RESULTING FROM APHASIA

Research shows that the aphasias usually result in more linguistic impairments than seen in normal aging individuals (Gleason & Goodglass, 1984). Aphasias can be classified as either fluent or nonfluent. Gleason and Goodglass (1984) describe fluency as the production of utterances with normal intonation, length, and grammatical correctness with unimpaired articulation by individuals with aphasia. The nonfluent aphasias, most commonly Broca's aphasia, often consist of single word productions or short, simple phrases containing only content words. Individuals with nonfluent aphasia use few sentence types, and complex syntax such as embedded clauses and grammar are not usually present (Gleason & Goodglass, 1984). The fluent aphasias are usually characterized as having speech with accurate syntactic and grammatical utterances. Individuals with fluent aphasia produce long, simple sentences

(Gleason & Goodglass, 1984). Because the deficits resulting from the aphasias are well documented, many different treatments have been established to address the grammatical and syntactic impairments of PWA.

EXISTING APHASIA TREATMENTS

TRADITIONAL STIMULATION THERAPY

One of the most widely used approaches in aphasia therapy is Schuell's (1964) stimulation approach (Coelho, Sinotte, & Duffy, 2008). The stimulation approach can be defined as "the approach to treatment that employs strong, controlled, and intensive auditory stimulation of the impaired symbol system as the primary tool to facilitate and maximize the patient's reorganization and recovery of language" (Coelho, et al., 2008, p. 406). Schuell (1964) believed that language was not lost in aphasia but rather worked at reduced efficiency. Because Schuell believed that auditory processes aided the processing and control of language, many of the therapy tasks emphasized auditory processes (Coelho et al., 2008). The following studies provide evidence that traditional stimulation therapy is effective.

In a study that followed the stimulation approach, Basso, Capitani, and Vignolo (1979) examined oral expression, auditory comprehension, reading, and writing of 162 people with aphasia and 119 controls. Therapy included individual 45-50 minute sessions three times a week for 5 months that consisted of language exercises. These exercises were "viewed as a stimulus-response situation in which the therapist endeavors to elicit and consolidate language responses by giving stimuli and reinforcements" (p. 192). The researchers did not use standardized measures but rather rated each language modality from 0 (no communication) to 4 (very good communication). Following treatment, the researchers found more improvement on all four language measures for the individuals who received therapy than for those who did not (Basso,

Capitani, & Vignolo, 1979). The researchers' findings of improvement on all language measures supported the findings that traditional aphasia treatment effectively produces gains in language production for PWA. However, the outcome measure chosen, rating communication for each modality, did not allow for assessment of specific linguistic changes that measures of syntax and semantics changes might provide.

Another study investigated the effects of three treatments on language rehabilitation in individuals with aphasia (Shewan & Kertesz, 1984). This study included 100 people two to four weeks post left cerebrovascular accident who received therapy for one year. All aphasia severity levels and classification types were included. Participants were assigned to one of three groups. One group received therapy based on psycholinguistic principles, another received stimulation-facilitation therapy, and the last group received unstructured stimulation facilitation therapy focused on psychological support provided by nurses. To determine treatment efficacy, the investigators used the *Western Aphasia Battery* (WAB; Kertesz, 1982) Language Quotient (LQ) and Cortical Quotient (CQ). All three groups improved, based on the LQs and CQs, which led the researchers to conclude that increases in these measures indicated positive changes in language performance. All three treatments were effective; however, no specific treatment was found to be more effective than another (Shewan & Kertesz, 1984). Similar to Basso et al.'s (1979) study, this study also shows that traditional stimulation therapy results in language improvements; however, Shewan and Kertesz used standardized measures to evaluate the treatment's effectiveness which did not provide specific information regarding linguistic complexity.

Both of the studies just described support the fact that traditional stimulation therapy is effective for treating the language deficits resulting from the aphasias when measured by

standardized aphasia tests. However, there is little research evaluating whether increases in standardized aphasia test scores reflect changes that improve daily communication. There are also no studies directly evaluating the changes following traditional therapy by measuring changes in linguistic complexity. Furthermore, there is little research to support that language performance gains made in traditional therapy generalize to everyday communication, specifically conversation (Simmons-Mackie, 2008). Having a successful conversation is an important component of daily communication and life participation (Fox et al., 2009) because it is the most frequently used communication style of PWA (Davidson, Worrall, & Hickson, 2003).

CONVERSATION THERAPY

The primary aim of speech and language therapy for aphasia is to maximize individuals' ability to communicate (Brady, Kelly, Godwin, & Enderby, 2012) given that conversational interaction is central to participating in one's everyday life activities (Fox et al., 2009). It is the most natural and the most frequently used communication style for older adults with and without aphasia (Davidson, Worrall, & Hickson, 2003). Most people directly relate their quality of life to their communicative abilities (Saloman, Vestrager, & Jahd, 1988). Particularly, aphasia therapy should target natural communication in natural settings. This approach led to the use of group therapy for people with aphasia because it is thought to mimic natural conversational settings. Group therapy integrates treatment into natural communicative settings to facilitate carryover to everyday communication. Researchers have studied group aphasia therapy by utilizing a variety of discourse management features so that therapy reflects everyday communication. These features included "establishing the feeling of discourse equality, focusing on everyday communicative events and genres, employing multiple communication modes, mediating communication, calibrating corrections, aiding turn allocation, and judiciously

employing teachable moments” (Simmons-Mackie et al., 2007, p. 18). Up to now, group conversational therapy has been difficult to replicate due to lack of documentation on how to conduct it and because each investigator has used his/her own outcome measures, which have primarily included standardized tests (Brumfitt & Sheeran, 1997).

The assumption that investigators have made is that using conversation in group therapy leads to improved performance on a number of language processes (repetition, naming, fluency, and comprehension) which standardized aphasia tests measure. However, researchers have not measured the outcome of conversation group therapy on conversation outcomes (Savage, Donovan, & Hoffman, 2013). In fact, we do not know if the language structure of conversations (e.g. increased vocabulary/word usage, morphology, grammar and syntax) has improved after conversation therapy because investigators have not measured it. To confound the situation further, the field has accepted the use of group aphasia conversation therapy without any study of whether or not conversation therapy is efficacious for PWA in individual treatment.

Some studies have examined changes in conversational interactions based on training the person with aphasia’s conversation partner. Fox et al. (2009) investigated effects of conversational treatment on an individual with mild aphasia and her communication partner. The woman with aphasia was one year post stroke, and the couple reported dissatisfaction with their conversations. Four baseline sessions, 14 treatment sessions, and two follow-up sessions were completed, with each session lasting 60 minutes. Ten-minute conversations between the couple were video-recorded for baselines, weekly therapy probes, and follow-ups. Therapy was based on procedures used by Boles (1998). During the sessions, the couple had a series of three-minute conversations on topics they chose. The clinician provided feedback related to the therapy goals and the couple was allowed self-reflection after each conversation. Outcome

measures included satisfaction ratings by the couple regarding their conversations, independent judges' ratings of the couple's conversations on the Measure of skill in Supported Conversation (MSC) and the Measure of Participation in Conversation (MPC) (Kagan et al., 2004), and behavior measures regarding goals set by the couple and the clinician. Ratings on the MSC and MPC improved, indicating that the independent judges' ratings of the couple's conversation abilities improved post-treatment. The couple's ratings of satisfaction improved and the researchers noted some improvement on the behavior goals, although it was inconsistent.

This study provides evidence that conversation therapy results in improved perception of success during conversations by individuals with aphasia and their communication partners; but the outcome measures used in this study did not address the linguistic deficits common in mild to moderate aphasia. The following study also examined a conversational therapy that incorporates training individuals with aphasia and their communication partners strategies to have a more successful conversation.

Hopper, Holland, and Rewega (2002) examined the effects of a conversation coaching treatment. Two couples participated in this multiple, single-subject design. Both couples consisted of an individual with aphasia and his/her communication partner. The couples attended baseline sessions, an instructional session where facilitative strategies were discussed, ten treatment sessions, and two post-treatment probe sessions (1 week post and 3 months post). During the ten therapy sessions, the individuals with aphasia watched a video and had to describe the video to their partners. The clinician provided feedback such as coaching the participants to use alternative communication strategies when a communication breakdown or a miscommunication occurred. Outcome measures were number of main concepts successfully communicated, standardized testing using the *Communication Activities of Daily Living-Second*

Edition (CADL-2; Holland, Frattali, and Fromm, 1999), and social validation ratings. Both couples increased their percent of main concepts communicated about the videos up to 3 months post-treatment. One of the individuals with aphasia showed an increase in the CADL-2 score. Social validation ratings increased with students better understanding conversations post-treatment than pre-treatment.

This study is important because it shows that coaching individuals with aphasia and their communication partners using conversation therapy results in improvements on multiple types of outcome measures. The outcome measures used in this study, however, examined content of the conversations and not the form or structure of the language used by individuals with aphasia during conversations. Furthermore, the previous two studies provide evidence demonstrating treatment efficacy for training conversational partners by showing increases on chosen outcome measures; however, neither of these studies examined the form or structure of the language used by the individuals with aphasia to determine effectiveness of treatment. Investigating form and structure of language using linguistic complexity measures would allow for examination of changes in the linguistic impairments of PWA as a result of treatment conducted in a more naturalistic way.

A NOVEL CONVERSATION THERAPY

To address the lack of research on the efficacy of conversation therapy, (Savage et al., 2013) studied a conversation treatment in which she targeted teaching individuals with aphasia strategies to improve their conversational abilities. She compared the treatment effects of conversation and traditional stimulation treatments on conversational outcomes. Four participants received both the conversation and the traditional stimulation treatments for ten sessions each (two sessions per week for 60 minutes each). Conversation outcomes included six-

minute conversation samples coded for pragmatic behaviors and percent of Correct Information Units (CIUs). Traditional stimulation outcomes included auditory comprehension, syntax performance, and lexical retrieval. Savage et al. (2013) found that syntax and conversation outcomes improved following traditional stimulation therapy. Three participants demonstrated the greatest increases in conversation outcomes during or following conversation therapy with percent CIUs increasing. She concluded that the participants had better discourse outcomes following conversation therapy than traditional therapy regardless of order received.

Although improved conversational interactions may be the ultimate outcome of aphasia treatment, no known studies have examined changes in linguistic complexity measures during conversational discourse treatment of PWA. In fact, linguistic complexity analysis has not extensively been applied in the aphasia treatment literature.

LINGUISTIC ANALYSIS

Although linguistic analysis has not been used in the aphasia treatment literature to evaluate changes in linguistic complexity, it has been applied in studies of children's language acquisition and studies of normal aging. Many researchers have examined verbal abilities by analyzing language samples (Capilouto et al., 2005; Kemper & Sumner, 2001; Kemper et al., 2001; Kynette & Kemper, 1986; Shewan & Henderson, 1988) although language sample analysis has typically been used to assess children's linguistic development (Heilmann et al., 2010; Price et al., 2010). Shewan and Henderson (1988) used picture description to elicit their language samples. Kemper and Sumner (2001) and Kemper, Thompson, et al. (2001) obtained oral language samples from elicitation prompts. Few if any studies in the aging literature involving language analysis have used conversation as the medium for obtaining language samples for analysis.

To analyze syntax, researchers have used the following measures: number of utterances (number of complete thoughts expressed), percent of complex utterances (utterances containing at least one independent clause and one or more dependent clauses, such as “He went to the store that was on the corner”) (Shewan & Henderson, 1988), number of different simple syntactic structures (basic sentences such as “The boy went to the store.”), number of complex structures (sentences with multiple embeddings such as “He did not know how to get to the store that is on the corner.”), mean length of utterance (MLU) (Kemper & Sumner, 2001; Kynette & Kemper, 1986), number of different verb tenses (past- “jumped,” present- “walks,” future- “will ride,” etc.) and percent of verb tenses correctly produced (Kynette & Kemper, 1986). These measures allow for examination of syntax from language samples and can be applied to conversational discourse samples.

To analyze lexical variables such as vocabulary, researchers have examined the total number of different words and type/token ratio (Kemper & Sumner, 2001; Kynette & Kemper, 1986). Type/token ratio (TTR) “is a measure of the number of different words used in a language sample to the total number of words occurring in the sample. A TTR close to 1.0 indicates that every word is novel, whereas a TTR close to 0.0 indicates a limited, repetitive vocabulary” (Kemper & Sumner, 2001, p. 313). Kemper and Sumner (2001) found that young adults’ (ages 18-28) average TTR was around 0.47 while older adults’ (ages 63-88) average TTR was around 0.58.

The use of linguistic analysis in the child language development and aging literature to document linguistic change is abundant. The studies cited incorporate multiple linguistic measures of syntax and semantics to document and describe the changes in linguistic complexity across the lifespan. Although linguistic complexity measures are frequently used, they have not

yet been applied in the aphasia treatment literature to monitor progress made in linguistic rehabilitation. Linguistic complexity outcome measures would allow for assessment and monitoring of the rehabilitation of linguistic deficits resulting from the aphasias.

RESEARCH QUESTIONS

The aphasia treatment literature substantiates the fact that aphasia can be associated with limited expressive vocabularies and reduced syntactic complexity depending on type and severity. The aim of the present study was to determine whether conversation therapy results in greater increases in linguistic complexity than traditional stimulation therapy. To accomplish this aim, I investigated the following research questions:

1. Does Conversation therapy (Ctx) lead to a greater increase in linguistic complexity than Traditional stimulation therapy (Ttx) based on the following measures of linguistic complexity:
 - a) Mean length of utterance (in words) (MLU)?
 - b) Type/token ratio (TTR)?
 - c) Number of different words (NDW)?
 - d) Percent of utterance responses?
 - e) Percent of simple utterances?
 - f) Percent of complex utterances?

METHODS

DESIGN

This is an exploratory study based on two cases taken from a prospective, single subject, ABABA treatment study replicated across four individuals with aphasia (Savage et al., 2013). The purpose of this study was to determine if conversational therapy results in greater increases in linguistic complexity outcomes than traditional therapy.

PARTICIPANTS

Savage et al. (2013) recruited four individuals with mild to moderate aphasia who met the following inclusion criteria: 1) first time, acquired left hemisphere focal lesion resulting from a cerebrovascular accident (CVA), in the language processing centers of the brain, as determined by medical records obtained by investigator; 2) at least 6 months post-onset at the time of initial testing; 3) between the ages of 18-89 years; 4) native English speaker; 5) right hand dominant; 6) with no other history of or active neurological disorders, language disorders, substance abuse, or psychiatric illness per caregiver report; 7) at least a high school level of education; 8) adequate vision and hearing based on screening assessments; 9) mild to no apraxia of speech; 10) community-dwelling; and 11) not receiving any other speech or language therapy for the duration of the study. See Table 1 for participant characteristics.

Table 1. Participant Characteristics

Participant	Gender	Age	Years Post-Onset	Years of Education	* AQ	Premorbid Handedness	Hearing	Vision	Clock Drawing
P01	M	74	2;10	24	91.5	Right	Pass	Pass	WNL
P04	F	53	3;3	16	72.9	Right	Pass	Pass	Mild

*AQ = Aphasia Quotient (*Western Aphasia Battery – Revised*; Kertesz, 2007)

(Savage et al., 2013, p. 45)

DATA

The data for this study were derived from the transcripts of 17 conversational probes, approximately six minutes in length, collected for each participant during the Savage et al. (2013) study. All conversational probes were recorded and transcribed by trained laboratory assistants according to standard transcription conventions with adequate inter-rater and intra-rater reliability (Savage et al., 2013). Savage collected three baseline language probes for each A phase (A₁A₂A₃). During the 10 week treatment phases (B₁B₂), Savage collected probes at the start of each weekly session for a total of four samples per treatment phase.

PROCEDURES

In this study, the independent variable was type of treatment received by the participant: Ctx and Ttx. The dependent variables were MLU, TTR, NDW, percent of utterances, percent of simple utterances, and percent of complex utterances. See Table 2 for operational definitions used in analyses.

Two undergraduate student coders trained in the guidelines of the Systematic Analysis of Language Transcripts (SALT; Miller & Iglesias, 2010) coded the 17 language transcripts per participant using SALT conventions. The data for the measures MLU, TTR, NDW, percent of utterances, percent of simple utterances, and percent of complex utterances, were based on SALT output. The investigator entered the data into a research study database by participant code. These data were analyzed by the investigator.

SALT was used because it is a program specifically designed to analyze language transcripts from children and adults. It provided a means of consistent transcription because each code must be entered the same way in order to be identified. SALT allowed for analysis of

multiple levels of language including syntactic, semantic, lexical, and morphological (Miller, Freiberg, Rolland, & Reeves, 1992).

Table 2. Operational Definitions of Dependent Variables

Variable	Definition
Mean Length of Utterance -in words (MLU)	Average number of words per utterance in a given language sample.
Type/Token Ratio (TTR)	Ratio of the number of different words to the total number of words.
Number of Different Words	Number of different words spoken by the participant during a given language sample.
Percent of non-sentential utterances	Percent of verbal responses made by the participants that do not meet the criteria to be labeled as a simple or complex utterance
Percent of simple utterances	Percent utterances that contain a noun phrase and verb phrase and may have additional phrase elements (NP as a direct object, prepositional phrases).
Percent of complex utterances	Percent of utterances with clauses combined with a coordinate or subordinate conjunction, utterances with embedded clauses, and utterances that include only the embedded clause.

RELIABILITY

Prior to coding the conversation samples, coders received training on specific SALT codes and coding conventions established to capture the dependent variables. Coding was accomplished in two passes. In the first pass, the coder coded the language sample transcripts according to SALT conventions. In the second pass, the investigator coded the transcripts and compared results with first pass results. Discrepancies between the coders were resolved through discussion, review of coding manual, and retraining if needed. To further ensure reliability, 20% of the seventeen samples per participant were randomly selected and recoded to evaluate inter-rater reliability. Percentage of point-to-point agreement was computed. Acceptable inter-rater reliability was set at 90% or above.

The percentage of point-to-point agreement on coding the dependent variables on the transcripts was calculated by dividing the total number of agreements by the total number of agreements + disagreements. Inter-rater reliability was determined to be 99%.

DATA ANALYSIS

Single-subject design studies typically use two established methods to determine treatment effect, visual analysis and one statistical analysis (Olive & Smith, 2005, Beeson & Robey, 2006). I used effect size and visual inspection. I calculated effect size according to the Busk and Serlin (1992) method also described as the *standard mean difference* (SMD) effect size calculation (Beeson & Robey, 2006; Busk & Serlin, 1992; Olive & Smith, 2005; Robey, Schultz, Crawford & Sinner, 1999):

$$d = M_{A2} - M_{A1} / SD_{A1}$$

where: d is effect size

M_{A2} is the mean of the post-treatment probes;

M_{A1} is the mean of the baseline probes; and

SD_{A1} is the standard deviation of the baseline probes.

According to the literature, the benefit of calculating SMD is that it results in a d statistic, which allows the researcher to use Cohen's d effect size interpretation (i.e., 0.2 represents small effect, 0.5 represents moderate effect, 0.8 represents large effect) (Cohen, 1988) if no specific effect size interpretations exist (Olive & Smith, 2005; Beeson & Robey, 2006). I opted to use the same Cohen's d interpretation used by Savage et al. (2013) to maintain consistency in analysis of the data. Effect sizes were calculated for each variable comparing baseline phase (A_1) to post-treatment phase (A_2), baseline phase (A_1) to one-month follow-up phase (A_3), and post-treatment phase (A_2) to one-month follow-up phase (A_3).

Three judges who had no knowledge of the study visually inspected the graphed data by variable and judged if performance had improved from A_1 (baseline) to A_2 (post-treatment) and A_3 (treatment withdrawal/follow-up) (McReynolds & Kearns, 1983; Kearns, 2000). I also used a two *SD* band method (Ottenbacher, 1989) to establish a visual critical cut-off value set 2 *SD* above the baseline mean for each variable and each participant. The critical value was plotted on each graph prior to visual inspection. Treatment effect was present if at least two successive data points exceeded the critical cut-off value.

RESULTS

I asked: Does Conversation therapy (Ctx) lead to a greater increase in linguistic complexity than Traditional stimulation therapy (Ttx) based on the following measures of linguistic complexity:

- a) Mean length of utterance (in words) (MLU)?
- b) Type/token ratio (TTR)?
- c) Number of different words (NDW)?
- d) Percent of utterance responses?
- e) Percent of simple utterances?
- f) Percent of complex utterances?

Results are presented below for each outcome measure.

- a) MLU (in words)?

Table 3 shows the treatment effect sizes for MLU for P1 and P4. P1 demonstrated a small effect for Ttx ($d = 0.24$), a large negative effect for Ctx ($d = -1.46$), and an overall small negative effect after all therapy was removed ($d = -0.4$). P4 demonstrated a small negative effect for Ctx ($d = -0.3$), a moderate effect for Ttx ($d = 0.54$), and an overall small effect after all therapy was removed ($d = 0.19$). Both P1 and P4 demonstrated positive effects for Ttx and negative effects for Ctx for MLU, which revealed that Ttx resulted in greater gains in MLU than Ctx.

Table 3. Treatment effect results for mean length of utterance.

MLU	P1 Effect Size <i>d</i>	MLU	P4 Effect Size <i>d</i>
$A_1 \rightarrow A_2$ (Pre-Ttx \rightarrow Post-Ttx)	0.24	$A_1 \rightarrow A_2$ (Pre-Ctx \rightarrow Post-Ctx)	-0.3
$A_2 \rightarrow A_3$ (Pre-Ctx \rightarrow Post-Ctx)	-1.46	$A_2 \rightarrow A_3$ (Pre-Ttx \rightarrow Post-Ttx)	0.54
$A_1 \rightarrow A_3$ (Pre-therapy \rightarrow Post-therapy)	-0.4	$A_1 \rightarrow A_3$ (Pre-therapy \rightarrow Post-therapy)	0.19

Figures 1 and 2 depict P1 and P4's change in MLU across the 17 language samples. A bar was added to show the critical cut-off value $2 SD$ above the mean of the baselines (A_1) (P1 $M = 2.97$, $SD = 0.57$, $2 SD = 1.14$; P4 $M = 4.57$, $SD = 1.04$, $2 SD = 2.08$). Based on the design by Ottenbacher (1986), two successive points must fall above the critical cut-off value in order to conclude that performance improved. Neither P1 nor P4 had two successive points fall above the critical value for either treatment. Using this method of visual analysis, it was determined that P1 and P4 did not demonstrate improvement in MLU for Ctx or Ttx.

b) TTR?

Table 4 shows the treatment effect sizes for TTR for P1 and P4. P1 demonstrated a small effect for Ttx ($d = 0.4$), a moderate negative effect for Ctx ($d = -0.48$), and an overall small treatment effect from pre-therapy (A_1) to post-therapy (A_3) ($d = 0.25$). P4 demonstrated no effect for Ctx ($d = 0$), moderate/large effect for Ttx ($d = 0.75$), and an overall moderate treatment effect from pre-therapy to post-therapy ($d = 0.5$). Both P1 and P4 demonstrated positive effects for Ttx and no effect/negative effects for Ctx.

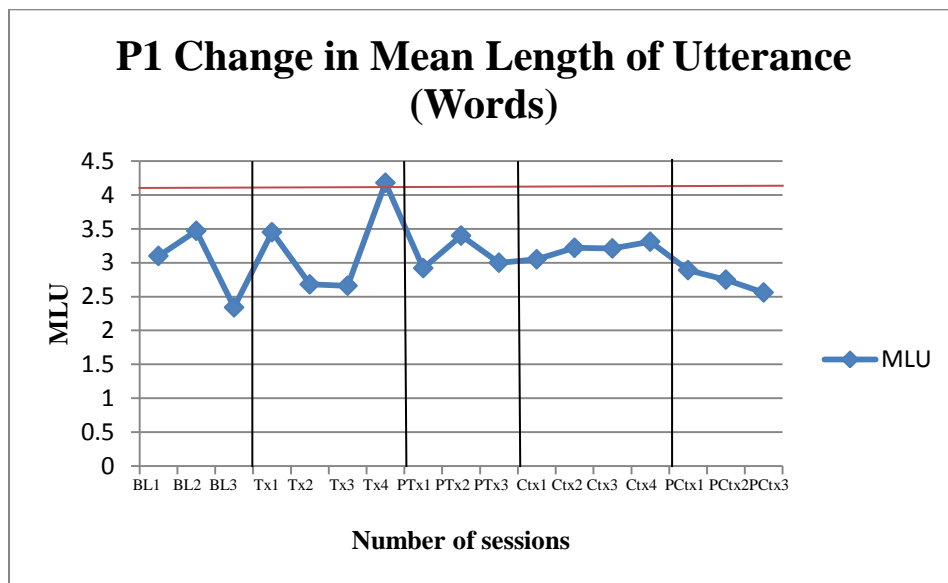


Figure 1. P1 change in MLU with red $2 SD$ bar indicating cut-off value (Ottenbacher, 1986).

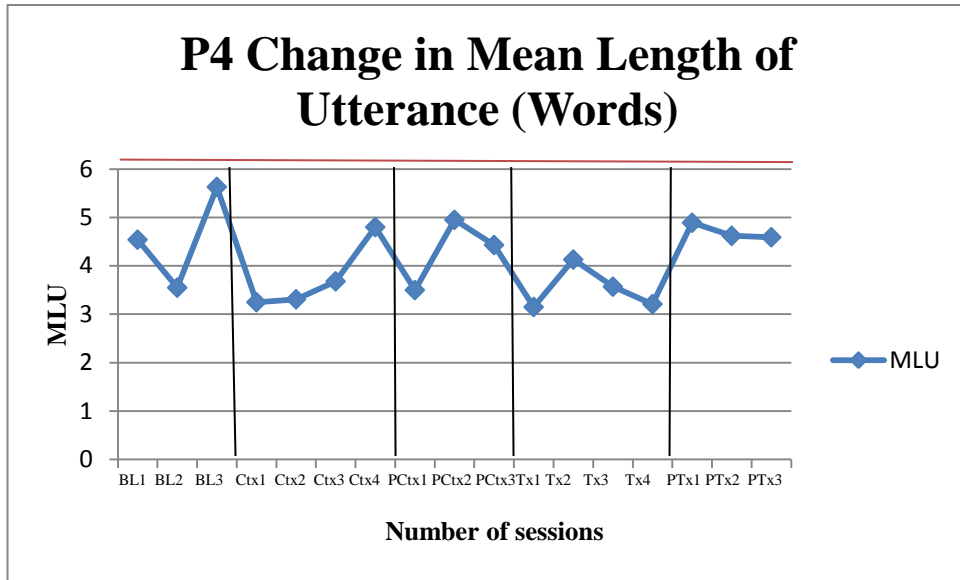


Figure 2. P4 change in MLU with red 2 *SD* bar indicating cut-off value (Ottensbacher, 1986).

Table 4. Treatment effect results for TTR.

TTR	P1 Effect Size <i>d</i>	TTR	P4 Effect Size <i>d</i>
A ₁ →A ₂ (Pre-Ttx→Post-Ttx)	0.4	A ₁ →A ₂ (Pre-Ctx→Post-Ctx)	0
A ₂ →A ₃ (Pre-Ctx→Post-Ctx)	-0.48	A ₂ →A ₃ (Pre-Ttx→Post-Ttx)	0.75
A ₁ →A ₃ (Pre-therapy→Post-therapy)	0.25	A ₁ →A ₃ (Pre-therapy→Post-therapy)	0.5

Figures 3 and 4 depict P1 and P4's change in TTR across the 17 language samples with the added bar indicating the critical cut-off value (P1 $M = 0.46$, $SD = 0.07$, $2 SD = 0.14$; P4 $M = 0.34$, $SD = 0.05$, $2 SD = 0.10$). Neither P1 nor P4 had two successive points fall above the critical value for either treatment. Using this method of visual analysis, P1 and P4 did not demonstrate improvement in TTR for Ctx or Ttx.

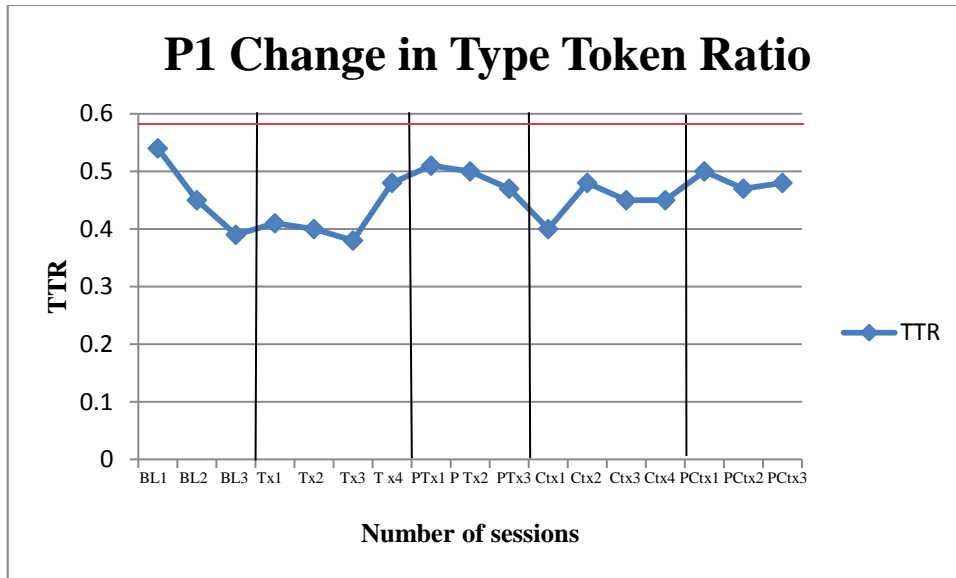


Figure 3. P1 change in TTR with red 2 SD bar indicating cut-off value (Ottenbacher, 1986).

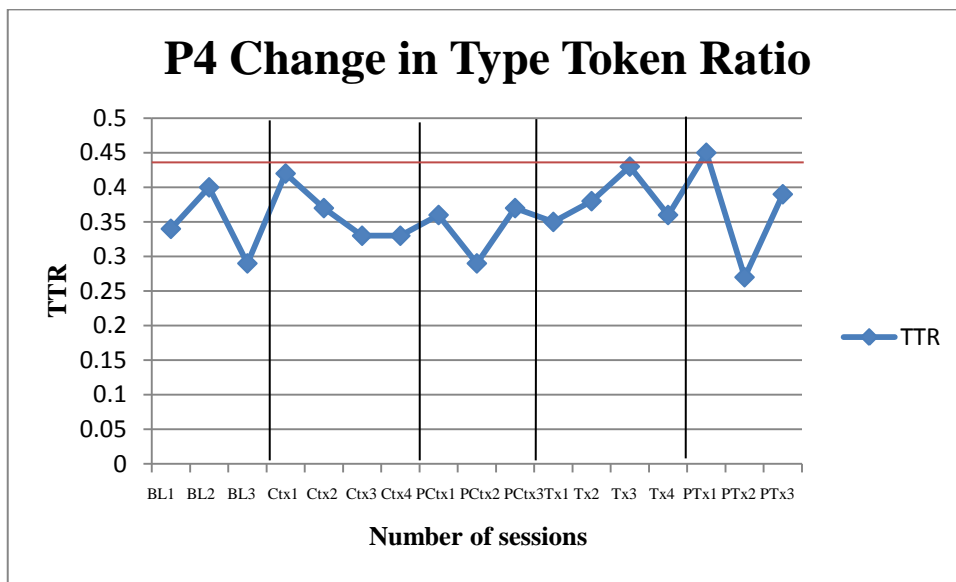


Figure 4. P4 change in TTR with red 2 SD bar indicating cut-off value (Ottenbacher, 1986).

c) Number of different words?

Table 5 shows the treatment effect sizes for P1 and P4 for number of different words. P1 demonstrated a large effect for Ttx ($d = 0.77$), small negative effect for Ctx ($d = -0.2$), and an overall moderate treatment effect ($d = 0.67$). P4 demonstrated a large effect for Ctx ($d = 1.03$),

and large negative effect for Ttx ($d = -1.13$), and an overall small negative effect from pre-therapy to post-therapy ($d = -0.27$).

Table 5. Treatment effect results for number of different words (NDW).

NDW	P1 Effect Size <i>d</i>	NDW	P4 Effect Size <i>d</i>
A ₁ →A ₂ (Pre-Ttx→Post-Ttx)	0.77	A ₁ →A ₂ (Pre-Ctx→Post-Ctx)	1.03
A ₂ →A ₃ (Pre-Ctx→Post-Ctx)	-0.2	A ₂ →A ₃ (Pre-Ttx→Post-Ttx)	-1.13
A ₁ →A ₃ (Pre-therapy→Post-therapy)	0.67	A ₁ →A ₃ (Pre-therapy→Post-therapy)	-0.27

Figures 5 and 6 depict P1 and P4's change in NDW across the 17 language samples with the added bar indicating the critical cut-off value (P1 $M = 69$, $SD = 15.5$, $2 SD = 31$; P4 $M = 134$, $SD = 26.2$, $2 SD = 52.4$). P4 did not have two successive points fall above the critical value for either treatment, indicating no improvement in NDW for either treatment type. P1 had two successive points fall above the critical value for Ctx, indicating an improvement in NDW due to Ctx; however, visual inspection and effect sizes revealed that this improvement was not maintained following treatment removal.

d) Percent of utterance responses?

Table 6 shows the treatment effect sizes for percent of utterances for P1 and P4. P1 demonstrated a moderate negative effect for Ttx ($d = -0.5$), large effect for Ctx ($d = 1.4$), and an overall large effect from pre-therapy to post-therapy ($d = 1.25$). P4 demonstrated a moderate/large effect for Ctx ($d = 0.7$), a large negative effect for Ttx ($d = -0.83$), and an overall small effect from pre-therapy to post-therapy ($d = 0.2$). Both participants demonstrated moderate to large negative effects for Ttx and large effects for Ctx. Unlike the other five measures, a

negative effect for percent of utterance responses was desirable because the participants would be demonstrating less one or two word phrases and incomplete thoughts.

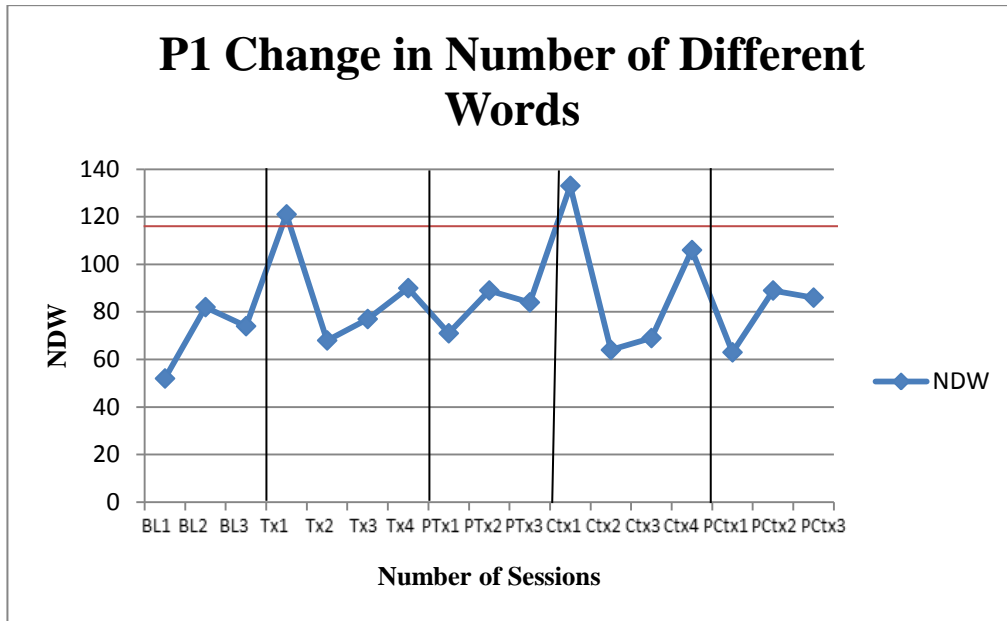


Figure 5. P1 change in NDW with red 2 SD bar indicating cut-off value (Ottenbacher, 1986).

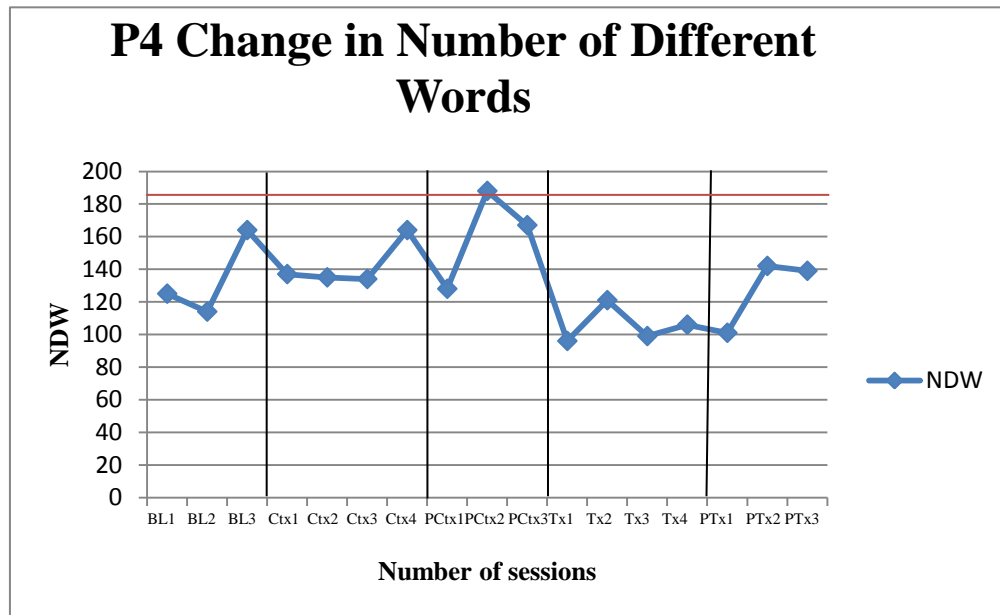


Figure 6. P4 change in NDW with red 2 SD bar indicating cut-off value (Ottenbacher, 1986).

Table 6. Treatment effect results for percent of utterances.

% Utterances	P1 Effect Size <i>d</i>	% Utterances	P4 Effect Size <i>d</i>
A₁→A₂ (Pre-Ttx→Post-Ttx)	-0.5	A₁→A₂ (Pre-Ctx→Post-Ctx)	0.7
A₂→A₃ (Pre-Ctx→Post-Ctx)	1.4	A₂→A₃ (Pre-Ttx→Post-Ttx)	-0.83
A₁→A₃ (Pre-therapy→Post-therapy)	1.25	A₁→A₃ (Pre-therapy→Post-therapy)	0.2

Because the desire was for percent of utterance responses to decrease, the visual analysis using the 2 *SD* band method needed to be altered to capture the appropriate change. The critical cut-off value was set 2 *SD* below instead of above the baseline mean. Figures 7 and 8 depict P1 and P4's change in percent of utterance responses across the 17 language samples with the added bar indicating the critical cut-off value (P1 $M = 73$, $SD = 4$, $2\ SD = 8$; P4 $M = 47$, $SD = 10$, $2\ SD = 20$). Neither P1 nor P4 had two successive points fall below the critical value for either treatment, indicating no improvement for Ctx or Ttx.

e) Percent of simple utterances?

Table 7 shows the treatment effect sizes for percent of simple utterances for P1 and P4. P1 demonstrated a large effect for Ttx ($d = 2$), a large negative effect for Ctx ($d = -1.8$), and an overall very large negative treatment effect from pre-therapy to post-therapy ($d = -3.5$). P4 demonstrated a large negative effect for Ctx ($d = -1.5$), a moderate effect for Ttx ($d = 0.67$), and an overall large negative treatment effect from pre-therapy to post-therapy ($d = -1.6$). Both participants demonstrated large negative effects for Ctx, moderate to large positive effects for Ttx, and an overall large negative effect from pre-therapy to post-therapy for percent of simple utterances.

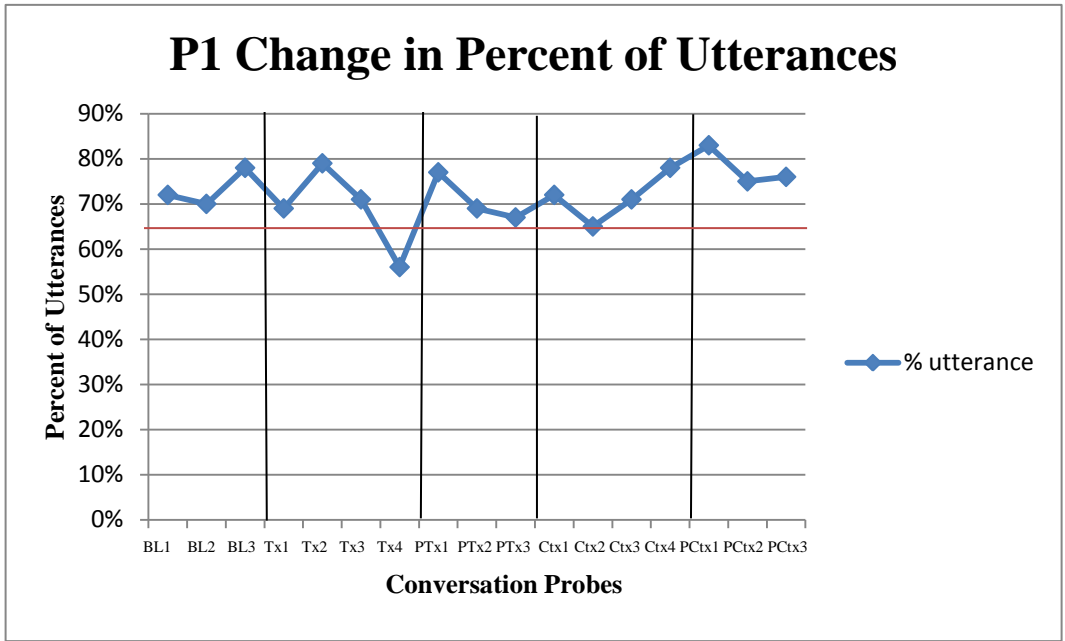


Figure 7. P1 change in percent of utterances with red 2 SD bar indicating cut-off value (Ottenbacher, 1986).

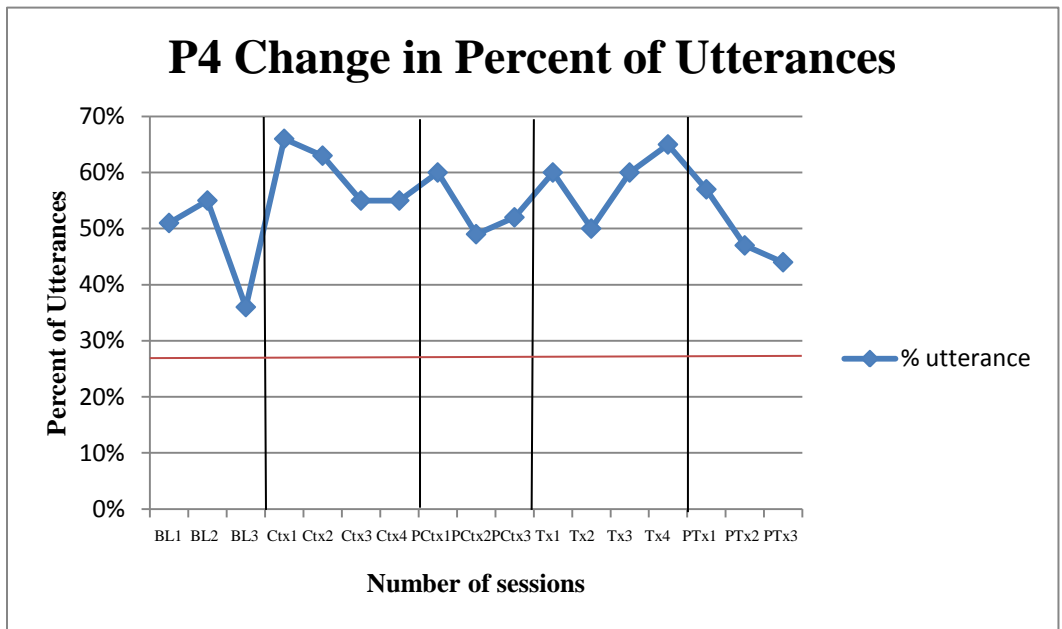


Figure 8. P4 change in percent of utterances with red 2 SD bar indicating cut-off value (Ottenbacher, 1986).

Table 7. Treatment effect results for percent of simple utterances.

% Simple	P1 Effect Size <i>d</i>	% Simple	P4 Effect Size <i>d</i>
A₁→A₂ (Pre-Ttx→Post-Ttx)	2	A₁→A₂ (Pre-Ttx→Post-Ctx)	-1.5
A₂→A₃ (Pre-Ctx→Post-Ctx)	-1.8	A₂→A₃ (Pre-Ttx→Post-Ttx)	0.67
A₁→A₃ (Pre-therapy→Post-therapy)	-3.5	A₁→A₃ (Pre-therapy→Post-therapy)	-1.6

Figures 9 and 10 depict P1 and P4's change in percent of simple utterances across the 17 language samples. A bar was added to show the critical cut-off value 2 standard deviations above the mean of the baselines (A₁) (P1 $M = 22$, $SD = 1.5$, $2 SD = 3$; P4 $M = 40$, $SD = 5.7$, $2 SD = 11.4$). P1 had two successive points fall above the critical value for Ttx, indicating an improvement in percent of simple utterances due to Ttx. P4 did not have two successive points fall above the critical value for either treatment, indicating no improvement in percent of simple utterances for either treatment type.

f) Percent of complex utterances?

Table 8 shows treatment effect sizes for percent complex utterances for P1 and P4. P1 demonstrated a small negative effect for Ttx ($d = -0.3$), a large effect for Ctx ($d = 1.3$), and an overall large treatment effect from pre-therapy to post-therapy ($d = 1$). P4 demonstrated a moderate effect for Ctx ($d = 0.5$), a small effect for Ttx ($d = 0.25$), and an overall large effect from pre-therapy to post-therapy ($d = 1$). P1 and P4 demonstrated a large and moderate effect, respectively, for Ctx.

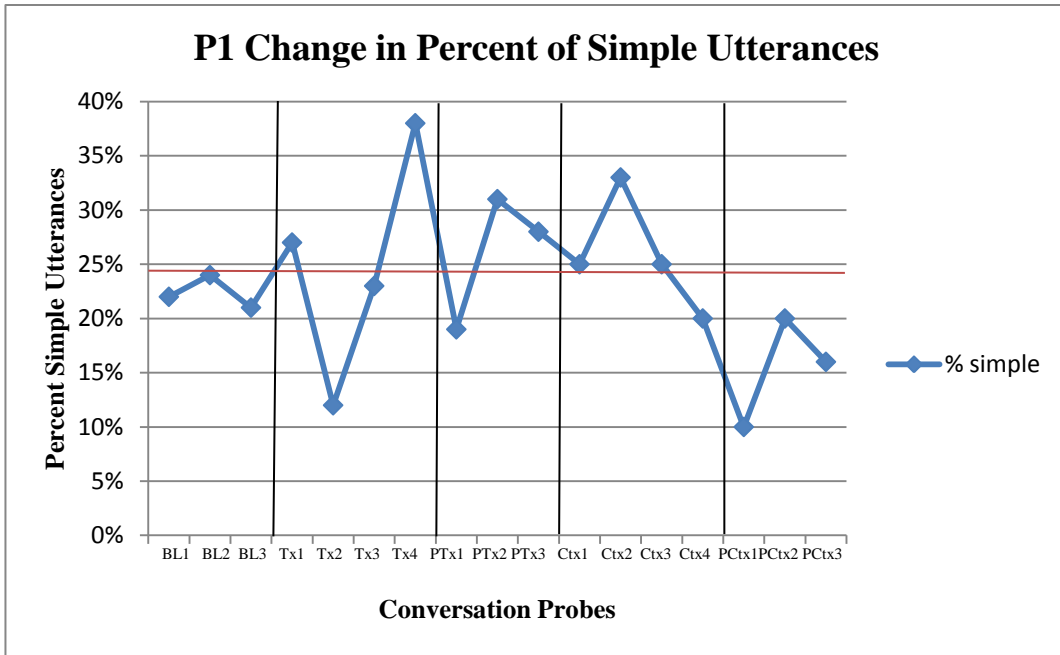


Figure 9. P1 change in percent of simple utterances with a red 2 SD bar indicating the critical cut-off value (Ottenbacher, 1986).

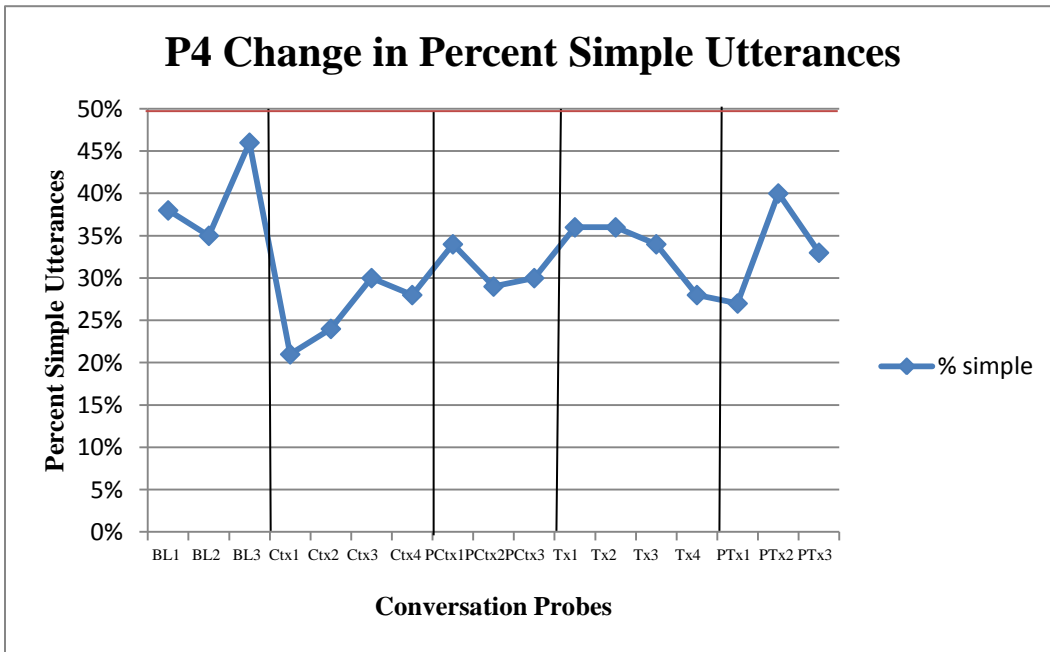


Figure 10. P4 change in percent of simple utterances with a red 2 SD bar indicating the critical cut-off value (Ottenbacher, 1986).

Table 8. Treatment effect results for percent of complex utterances.

% Complex	P1 Effect Size <i>d</i>	% Complex	P4 Effect Size <i>d</i>
A₁→A₂ (Pre-Ttx→Post-Ttx)	-0.3	A₁→A₂ (Pre-Ctx→Post-Ctx)	0.5
A₂→A₃ (Pre-Ctx→Post-Ctx)	1.3	A₂→A₃ (Pre-Ttx→Post-Ttx)	0.25
A₁→A₃ (Pre-therapy→Post-therapy)	1	A₁→A₃ (Pre-therapy→Post-therapy)	1

Figures 11 and 12 depict P1 and P4’s change in percent of complex utterances across the 17 language samples. A bar was added to show the critical cut-off value 2 *SD* above the mean of the baselines (A₁) (P1 *M* = 4, *SD* = 2.9, 2 *SD* = 5.8; P4 *M* = 13, *SD* = 4.4, 2 *SD* = 8.8). Neither P1 nor P4 had two successive points fall above the critical value for either treatment. Using this method of visual analysis, it was determined that P1 and P4 did not demonstrate improvement in percent of complex utterances for either treatment type.

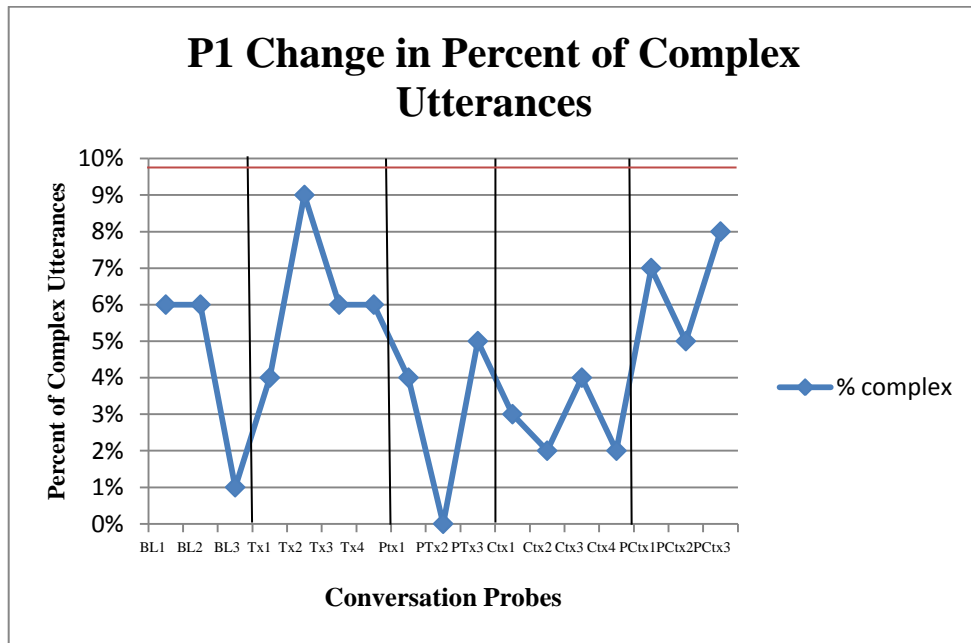


Figure 11. P1 change in percent of complex utterances with red 2 *SD* bar indicating critical cut-off value (Ottenbacher, 1986).

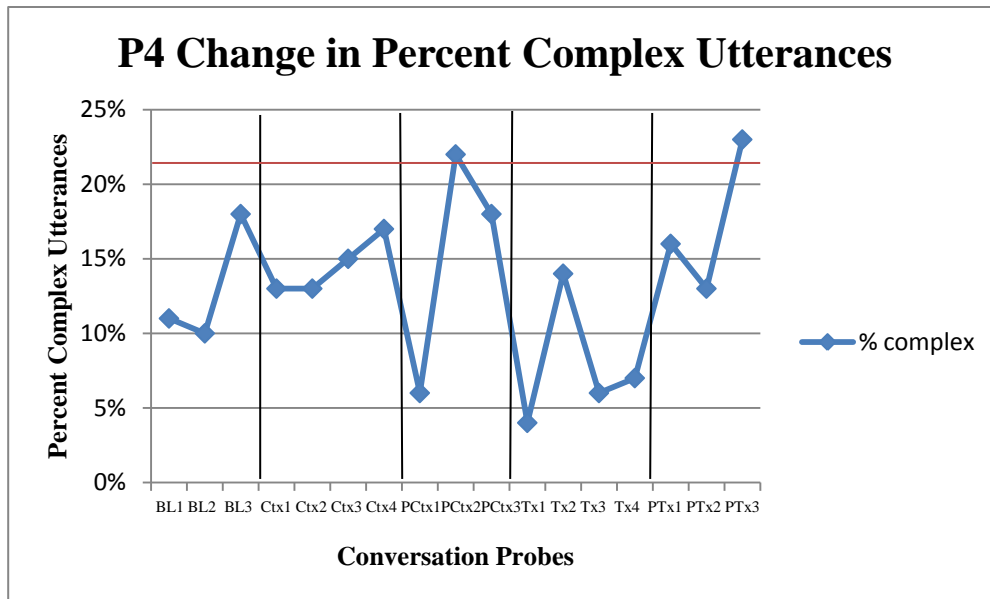


Figure 12. P4 change in percent of complex utterances with red 2 *SD* bar indicating critical cut-off value (Ottenbacher, 1986).

In summary, based on visual inspection using the 2 *SD* band method, the differences from the baseline conversation samples to the post-treatment conversation samples for MLU did not demonstrate enough change to meet the criteria for improvement. However, based on effect size, moderate positive treatment effects were noted for MLU for P1 and P4, respectively, for Ttx but not Ctx. For the measure, TTR, although the 2 *SD* band method revealed no substantial improvement for either participant, visual inspection of the graphs corresponds with the effect sizes. Both participants demonstrated positive effects for Ttx and negative effects for Ctx, signifying P1 and P4 showed greater increases in TTR following Ttx than Ctx. Examining the effect sizes for NDW, P1 demonstrated an effect for Ttx while P4 demonstrated an effect for Ctx. Visual inspection revealed that neither participant had 2 points fall above the critical cut-off value, thus there was no effect for either treatment.

To summarize percent of utterance results, although the 2 *SD* band method revealed no substantial improvement for either participant, visual inspection of the graphs corresponds with

the effect sizes. Both participants demonstrated negative effects for Ttx and positive effects for Ctx, signifying P1 and P4 showed greater decreases in the percent of utterance responses following Ttx than Ctx. To summarize percent of simple utterance data, combining the results from the 2 *SD* band method and effect sizes, P1 demonstrated substantial gains in Ttx for percent of simple utterances. Although visual analysis revealed that P4 did not demonstrate substantial improvement for either treatment, P4's percent of simple utterances increased more following Ttx ($d = 0.67$) than Ctx ($d = -1.5$). Lastly, combining the results for the 2 *SD* band method and effect sizes, neither P1 nor P4 demonstrated substantial improvements in percent of complex utterances following either treatment; however, both participants showed greater increases in percent of complex utterances following Ctx than Ttx. Tables 9, 10, and 11 depict these summarized results.

Table 9. P1 and P4 demonstrated greater effects in 4 measures following Ttx. Note that a negative effect was desirable for percent of utterances.

Variable	Participant	$A_1 \rightarrow A_2$ <i>d</i>	$A_2 \rightarrow A_3$ <i>d</i>	$A_1 \rightarrow A_3$ <i>d</i>
MLU	P1	0.24	-1.46	-0.40
	P4	-0.30	0.54	0.19
TTR	P1	0.40	-0.48	0.25
	P4	0.00	0.75	0.50
%utt	P1	-0.50	1.40	1.25
	P4	0.70	-0.83	0.20
% simple	P1	2.00	-1.80	-3.50
	P4	-1.50	0.67	-1.60

Table 10. P1 showed an effect following Ttx while P4 showed effect following Ctx.

Variable	Participant	$A_1 \rightarrow A_2$ <i>d</i>	$A_2 \rightarrow A_3$ <i>d</i>	$A_1 \rightarrow A_3$ <i>d</i>
NDW	P1	0.77	-0.20	0.67
	P4	1.03	-1.13	-0.27

Table 11. P1 and P4 demonstrated greater effects in % complex utterances for Ctx.

Variable	Participant	$A_1 \rightarrow A_2$ <i>d</i>	$A_2 \rightarrow A_3$ <i>d</i>	$A_1 \rightarrow A_3$ <i>d</i>
% complex	P1	-0.30	1.30	1.00
	P4	0.50	0.25	1.00

DISCUSSION

My study aimed to discover whether Ctx resulted in greater linguistic complexity gains than Ttx. I had hypothesized that Ctx would lead to greater changes in linguistic complexity than Ttx since, by its nature, conversation typically requires more complex utterances and varied vocabulary than those required during controlled treatment tasks. However, based on effect size analysis, both P1 and P4 demonstrated greater gains in four out of the six linguistic complexity measures following Ttx than Ctx including: MLU, TTR, % utterance responses, and % simple utterances. There were no consistent gains in one treatment type demonstrated by both participants for NDW. P1 demonstrated an increase in NDW following Ttx while P4 demonstrated an increase in NDW following Ctx. Both participants demonstrated greater increases in percent of complex utterances following Ctx than Ttx.

Ttx may have resulted in greater increases in MLU, TTR, percent of utterances, and percent of simple utterances because the treatment specifically targeted linguistic skills, whereas Ctx did not. Conversely, percent of complex utterances may have increased following Ctx due to the goals targeted for each participant during Ctx. For example, P1 was taught strategies to reduce repetitive phrases and expand his utterances beyond 'yeah,' 'ok,' and 'good.' Reducing the number of repetitive phrases, and thus increasing the number of different phrases as well as expanding his short utterances may have resulted in him using more complex language structures during conversation. P4's Ctx goals targeted story grammar and grammatical speech among others. However, it might also be possible that during conversations, complexity was not controlled for as it was in Ttx, allowing both participants unlimited opportunities to use more complex utterances than they did in Ttx.

Although some improvements were noted when effect sizes were examined, visual inspection using the 2 *SD* band method did not reveal results that agreed with the results of the effect size analyses. Because the baseline performance was not as stable as I would have liked, standard deviations were relatively high for both participants. Therefore, I suggest that the 2 *SD* critical cut-off value established for the study was a more stringent analysis than the effect size analysis where a large effect size is $\geq .8$ (Cohen, 1988). If the critical cut-off values had been displayed .8 on the graphs, perhaps it would have been easier for the judges to detect improvement.

The inconsistent gains attained during the two treatments may have resulted from the intensity and duration of the treatments. The participants received both treatment types two times per week at 60 minutes per session for a total of ten sessions. Savage et al. (2013) chose this treatment intensity and duration based on findings from Robey's (1998) meta-analysis and reimbursement by Medicare (Medicare, 2011). Robey (1998) determined that a minimum of two hours of therapy per week was needed to affect change, and current reimbursement provided by Medicare is ten sessions (Medicare, 2011). However, treatment durations were much longer in the studies Robey used in his meta-analysis. Therefore, we do not know the minimum number of sessions needed to affect change at two 60 minute sessions per week. It may be that the intensity, frequency, or the duration of the treatments needed to be greater to affect more change in the linguistic complexity measures for these participants with chronic aphasia.

The measures chosen for this study have not been applied as outcome measures for aphasia treatments. Many studies involving Ttx have determined treatment outcomes based on changes in standardized tests (Robey, 1998; Shewan & Kertesz, 1984; Wertz et al., 1986). Using standardized tests as treatment outcome measures does not allow for examination of

generalizability to conversation. Evidence suggests that Ttx does not generalize to untrained stimuli (DeDe et al., 2003; Ennis, 2001). Based on this evidence, I hypothesized that the participants' linguistic complexity would show greater increases following Ctx than Ttx. The results do not entirely support this hypothesis. This study provides some evidence that Ttx results in greater increases in linguistic complexity during conversation.

LIMITATIONS

There were several limitations to this study. One limitation was the study's duration—10 sessions per type of treatment. Savage et al. (2013) purposefully chose 10 sessions to reflect the typical standard of reimbursement for aphasia treatment at this time. However, because Ctx was a new treatment, a multiple baseline design that treated to a set criteria level may have been a more appropriate phase 1 design. A second limitation was that the conversation topics were not controlled. Over the course of time, the topics of conversation changed. In retrospect, early topics tended to be about personal factors related to family, hobbies, and interests. This sort of information is likely more rehearsed and thus easier to discuss than other topics. A third limitation may have had to do with participant variables such as age, time post-onset, and amount of therapy previously received. Although Savage et al. (2013) controlled for treatment fidelity, a fourth limitation was that each participant had a different clinician, which may have affected the study's outcomes. The two clinicians who treated P1 and P4 had qualitatively different discourse styles. One clinician spoke more often than the other, asked more yes/no questions, and provided more cues than the other clinician. This may have affected the quality of the conversational interactions between the participants and their therapists. As mentioned earlier, stable baseline measures were not achieved before treatment began. This caused the *SDs*

of the baseline outcome measures to be large and the critical cut-off value used to determine treatment effect in visual analysis to be set too high to reveal accurate treatment effect.

FUTURE RESEARCH

Participants in this study did not maintain the gains that were made during treatment when it was removed. However, the linguistic complexity outcome measures reliably captured the differences between Ttx and Ctx. This study provided preliminary evidence that Ttx results in greater increases in linguistic complexity than Ctx. Future studies could increase the intensity of the treatments to determine the length of time needed to demonstrate a stronger treatment effect. Since this was the first known study to apply these linguistic measures as treatment outcomes, future studies could extend the use of the measures to examine the change in language complexity following other language treatments.

CONCLUSION

In conclusion, this exploratory study found inconclusive, but promising results indicating that linguistic complexity measures may provide useful treatment outcome measures for researchers and clinicians interested in treating PWA. For those who believe that improved conversational interactions is the ultimate outcome of aphasia treatment, and that improved conversational interactions lead to increased quality of life, this work provides opportunities for further research.

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