Title: Comparing linguistic complexity and efficiency in conversations from Stimulation Therapy and Conversation Therapy in Aphasia.

Background:

The ultimate goal for speech language pathology interventions for people with aphasia (PWA) is to be able to converse as normally as possible (Armstrong & Mortensen, 2006). However, there are numerous approaches to aphasia therapy as well as various outcome measures. For instance, Stimulation therapy (ST) relies on structured repetition and drill to elicit language, while conversation therapy (CT) uses client-clinician conversation and conversation analysis to improve everyday language. Most speech language pathologists use standardized tests or rating forms to measure treatment progress rather than measuring conversations (Boles, 1998).

We aimed to compare differences in linguistic complexity and efficiency in conversational outcomes in two treatment types, ST and CT. Researchers have examined the verbal abilities of PWA and aging adults by analyzing language samples (Capilouto et al., 2005; Kemper & Sumner, 2001); however few people have examined linguistic complexity in conversation as a treatment outcome measure.

Conversational efficiency measured in Correct Information Units (CIUs)/minute is a valid and reliable way to measure improvement in connected speech (Nicholas and Brookshire, 1993). Efficiency can be measured by calculating CIUs/minute or % CIUs. Researchers have used %CIUs to measure efficiency in conversations (Doyle, Goda & Spencer, 1995) and CIUs/minute in story-telling (Jacobs, 2001). However, no one has reported using CIUs/minute to measure efficiency during conversational interactions.

To address this we asked the following questions:

1. Does CT lead to a greater increase in linguistic complexity than ST 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?
    g) Propositional density?
2. Does ST lead to improved efficiency of conversation?
3. Does CT lead to improved efficiency of conversation?
4. Is conversational efficiency different when ST is compared to CT?
5. Is there a difference between clinician and participant total talk time during conversation probes taken during both treatments?

Method

This study uses two cases of people with anomic aphasia from a prospective single subject ABABA treatment study replicated across participants approved by the University's Institutional Review Board (Collins, 2012). One participant (P01) was a 74-year-old right-handed male with 24 years of education; 34 months post left CVA, *Western Aphasia Battery* Aphasia Quotient of 91.5 (mild); and no apraxia of speech. The other participant (P04) was a 53-year-old right-handed female with 16 years of education; 39 months post left CVA; *Western Aphasia Battery* Aphasia Quotient of 72.9(moderate);

and no apraxia of speech. Both participants passed screenings for vision, hearing, and cognition.

In the original experiment, the participants received two treatments—ST and CT—administered in two 60-minute sessions/week for 10 sessions each. Seventeen 6-minute (average) language samples were collected over the course of the study; three during each A phase (baseline, withdrawal, post-treatment), and 4 during each B phase (ST, CT). Undergraduate assistants trained in transcription and blinded to the study's purpose transcribed the audio-recorded samples verbatim, coded all samples using Systematic Analysis of Language Transcripts, Version 8.0 (SALT; Miller & Iglesias , 2010), and calculated CIUs/utterance.

In the current study the dependent variables included linguistic complexity variables for question 1; CIU/minute in ST and CT for questions 2-4; and clinician and participant total talk times for question 5.

To measure CIU/minute, a research assistant analyzed the 17 conversation samples per participant by timing each utterance to seconds and tenths of seconds using the Stopwatch application on the iPhone 4 calibrated with a standard stopwatch. To calculate CIUs/minute, she divided the total number of CIUs by total talk time. The data for linguistic complexity variables were based on SALT output, except for propositional density, which was entered into Computerized Propositional Idea Density Rater (CPIDR; Brown, et al., 2008).

For linguistic complexity, the investigator measured point-to-point inter-rater reliability on 20% of the seventeen samples per participant was 99% agreement. For CIUs, intra-rater reliability was calculated by the research assistant who re-timed all samples and re-checked calculations for correctness. A person blinded to the study's purpose timed 20% of the samples' middle 3 minutes of conversation to calculate inter-rater reliability. Times were compared point-to-point within one-tenth second for agreement. Inter-rater reliability was 90% agreement.

Data Analysis:

Results for linguistic complexity variables were analyzed using effect sizes (Busk & Serlin, 1992) and visual inspection using the 2 *SD* band method (Ottenbacher, 1986). The two *SD* band method was established by setting a critical cut-off value 2 *SD* above the baseline mean for each outcome measure and each participant. Treatment effect was present if at least two successive data points exceeded the critical cut-off value. We used independent *t*-tests for Q2, Q3 and Q5, and paired samples *t*-test for Q4.

Results: (please note results for Q1-4 are presented for P01 and P04 results are undergoing analysis)

Q1: Both participants demonstrated greater effects for four of the six linguistic complexity measures following ST than CT: MLU, TTR, % utterance responses, and % simple utterances. P01 demonstrated an effect in NDW following ST while P4 demonstrated an effect in NDW following CT. Both participants demonstrated greater effects in percent of complex utterances following CT than ST. Both participants demonstrated large effects in propositional density following CT (see Table 2). Visual inspection revealed an effect for P01's % simple utterances following ST.

Q 2-4: There was no significant difference found for CIUs/min in ST or CT or between the two treatments for both participants.

Q5: In comparing the P01's total talk time including both treatments (M = 1.90, SD = 0.73) to the clinician's (M = 1.04, SD = 0.49), the participant had significantly longer total talk time, $t(28) = 4.08$, $p = 0.00$. Further analyses revealed that the total talk time for ST (M = 1.63, SD = 0.48) compared to the total talk time during CT (M = 2.09, SD = 0.80), was significantly different t (9) = -2.45, $p = 0.04$. Furthermore, during ST, the participant's total talk time (M = 1.99, SD = 0.39) was not significantly longer than the clinician's (M = 1.36, SD = 0.69), $t(28) = 1.59$, $p = 0.16$. However, during CT, the participant's total talk time during CT (M=2.42, SD=1.06) was significantly longer than the clinician's (M = 0.72, SD = 0.44), $t(28) = 2.99$, $p = 0.02$. For P02 the total talk time difference between the clinician (M = 116.41, SD = 31.9) and participant (M = 140.0, SD = 40.2) was not significant $t(32) = -1.9$, $p = .06$.

Conclusions:

This study attempted to profile the conversational abilities for two PWA based on two types of therapy. These limited results may suggest that conversation therapy has an effect on increasing the number of ideas conveyed and the complexity of language used. This study also suggested that these linguistic complexity and efficiency measures can be used reliably to measure as treatment outcomes.

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Table 1

Operational Definitions of Dependent Variables

Variable	Definition
Type/Token Ratio (TTR)	Ratio of the number of different words to the total number of words.
Mean Length of Utterance -in words (MLU)	Average number of words per utterance in a given language sample.
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.
Propositional density	Propositional density is the quotient of the number of ideas conveyed and the total word count.

Table 2

Effect Sizes for Linguistic Variables

Variable	ID #	A1-A2 *d*	A2-A3 *d*	A1-A3 *d*
MLU	P01	.24	-1.46	-.40
	P04	-.30	.54	.19
TTR	P01	.40	-.48	.25
	P04	0.00	.75	.50
NDW	P01	.77	-.2	.67
	P04	1.03	-1.13	-.27
% of utterance	P01	-.50	1.40	1.25
	P04	.70	-.83	.20
% of simple utterances	P01	2.00	-1.80	-3.50
	P04	-1.50	.67	-1.60
% of complex utterances	P01	-0.3	1.3	1
	P04	0.5	.25	1
propositional density	P01	.3	.8	1.95
	P04	.8	.4	.3