CHANGES IN DISCOURSE PRODUCTION FOLLOWING LEFT HEMISPHERE STROKE

A Thesis

Presented to

The Faculty of the Department

of Communication Sciences and Disorders

University of Houston

In Partial Fulfillment

Of the Requirements for the Degree of

Master of Arts

By

Amanda N. Clark

May, 2018

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ABSTRACT

Discourse is any unit of connected speech longer than a sentence, organized sequentially and logically, to effectively communicate a group of ideas to a listener (Kong, 2016). Discourse can become impaired following injury to the brain, resulting in either acute impairments that get better over time, or residual chronic communication impairments (e.g., aphasia). This study used a modified multi-level analysis developed by Marini and colleagues (2011, 2012, 2014, 2015) comprised of microlinguistic and macrolinguistic variables to examine whether acute left hemisphere stroke patients experience deficits in discourse and how those deficits change over time as reorganization and recovery takes place. A picture naming task and a narrative retell task were administered to 16 patients at bedside acutely (2-7 days post stroke), then again sub-acutely (1-3 months post stroke), and the results of the discourse measures were compared with the data of 14 control subjects. Results indicated that 69% of our population had some type of discourse deficit acutely, either microlinguistic or macrolinguistic, compared with the data from controls. For our population at the acute stage, 69% of subjects showed deficits on macrolinguistic aspects of discourse, whereas 50% of subjects showed deficits on microlinguistic aspects of discourse, indicating that macrolinguistic deficits were more prevalent for our cohort. A subset of subjects demonstrated significant macrolinguistic deficits without the presence of microlinguistic deficits. These results support previous aphasia research stating that aphasia batteries may not be sensitive enough to detect subtle discourse deficits in this population. Results also indicated a relationship between lexical retrieval (picture naming) and cohesion for the acute population, but correlations did not hold at the sub-acute time point due to subjects performing at ceiling on the naming measure. These data are supportive of the need for multilevel analysis to examine changes in discourse and show that discourse deficits may be missed using traditional aphasia batteries which detect primarily microlinguistic variables.

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Table of Contents

I. Introduction

Communication is central to the social and mental wellbeing of people because we rely heavily on social constructs and interactions with others in our daily lives. People with language impairments experience a devastating impact on their quality of life when their communication deficits impact their personal and professional lives. Speech therapy can help to improve specific language deficits such as syntax, vocabulary, or articulation. However, the concept of discourse in communication is more complex and integrative than any one component of language production.

Discourse, referring to any unit of connected speech longer than a sentence, is a stream of verbal information, organized sequentially and logically, to effectively communicate a group of ideas to a listener (Kong, 2016). Discourse can be broken into sentences, and then further into propositions- or the smallest unit of idea in an utterance, consisting of a subject, verb, and modifiers (Barker, Young, & Robinson, 2017). Discourse produced by speakers with communication disorders provides a rich sample for researchers to understand the manifestation of specific symptoms of a disorder (Kong, 2016). Discourse and speech can become impaired following injury to the brain, resulting in either acute impairments that get better over time, or residual chronic communication impairments (e.g. aphasia). Studying disordered discourse production is helpful for researchers and clinicians in speech language pathology, psychology, linguistics, or other communication related health professions. Looking at patterns of impairments in discourse gives clinicians and scientists a better understanding of underlying linguistic and cognitive processes that are part of the system for discourse and language production (Linnik, Bastiaanse, & Hohle, 2016). An in depth understanding of strengths and weaknesses of a client's discourse production can also be helpful for clinicians creating goals for therapy. Because discourse impairment can occur across various populations (for example, individuals with aphasia due to stroke, traumatic brain injury, dementia, and Alzheimer's) it is crucial that there are efficient assessments available to health care providers to detect discourse impairment as well as quality research proving which treatments lead to improvement for a specific deficit. Assessments should be sensitive enough to reveal whether a client is benefitting from treatment (Kong, 2016).

Underlying neural mechanisms supporting discourse are not well understood, but it is clear that adequate production of discourse requires a group of cognitive processes to interact together, while also responding to external social factors (Linnik et al., 2016) . Discourse production in healthy populations has been studied extensively (Linnik et al., 2016). A speaker must be able to formulate a clear idea, organize the explanation, formulate the message, and produce the message, all while considering the perspective of the listener and monitoring cues from the environment (Kong, 2016). It requires the speaker to process and simultaneously respond to visual, verbal, and auditory input and output (Kong, 2016). This can only occur most effectively with adequate working memory, attention, and executive function (Kong, 2016).

Models of discourse production can be described as having three separate stages: *prelinguistic conceptualization, linguistic formulation, and articulation and monitoring of the message* (Barker et al., 2017). First, a communicative intent is developed. The speaker must mentally create a structure for the message they want to produce (Marini, Andreetta, Tin, & Carlomagno, 2011). This draws on conceptual framework of different types of discourse that must be retrieved from long-term episodic memory, such as selecting a schema for the appropriate "genre" of discourse. This structure must next be filled with content, or semantic information needed for the intended message. The speaker must also integrate what they are planning to say with what they said previously, while also monitoring and responding to extralinguistic content (pragmatic features or environmental stimuli) (Marini et al., 2011). The speaker must focus on their proposed topic of discourse, while simultaneously attending to new topics that are brought forward by conversational partners, as well as monitoring the flow of dialogue (Barker et al., 2017).

Most models of sentence formulation involve a multi-step process from idea generation to sentence output (Marini et al., 2011). During the phase of linguistic formulation, the speaker creates a plan for the preverbal message. Lexical processing retrieves lexical items stored in the mental lexicon that represent the intended meaning. This is a multiple-step process; stage one is lexical selection, and stage two is lexical access (Marini et al., 2011). Each lexical representation corresponding to a meaning has an activation threshold determined by the frequency of its use and the amount of time elapsed since it was last activated. A selection mechanism is used to accurately activate the desired lexical item while simultaneously inhibiting competing lexical items. Once a single lexical item is selected, the speaker gains access to its morphosyntactic, morphological features, syllabic, and phonological forms. This information from the lexical items that belong in the same sentence guide the process of creating the sentence by filling in the appropriate function words to make the lexical items associate meaningfully with each other, according to the preverbal intention of the speaker (Marini et al., 2011). Next the speaker accesses the phonologic and syllabic representations of the words, and this information is sent to the output system where articulation is coordinated by the motor system and then executed during speech production.

Linnik et al. (2016) outlined some basic concepts capturing how discourse can be explored at different levels. Useful concepts for this project include **informativeness, discourse structure, microlinguistic structure, macrolinguistic structure, cohesion, coherence,** and multilevel approaches. **Informativeness** refers to how much information content a speaker produces. This has historically been measured using an analysis of content units (CU) developed by Yorkston and Beukelman (1980) (as cited in Linnik et al, 2016, p. 768). A content unit is a group of information expressed in a unit by normal speakers (Linnik et al., 2016). Yorkston and Beukelman counted each content unit if it contained a word, a noun phrase, a verb phrase, or a prepositional phrase and a total number of content units was counted for a specific task (for example, picture description) if the content unit was produced by at least one participant. A similar measure was later devised by Nicholas and Brookshire (1993) to score correct information units (CIUs). They came up with a specific system for scoring the CIUs based on the criteria of single words that are accurate, informative, and relevant to the story being told (Nicholas & Brookshire, 1993). Both studies demonstrated that discourse produced by individuals with aphasia contained lower levels of informativeness in comparison to populations of healthy controls. The study of informativeness of discourse was established with these two first measures, and many alternative measurements continued to develop. Percent information units (%IU) was created and tested by McNeil, Doyle, Fossett, Park, and Goda (2001) and shown to be a highly reliable measure of informativeness for aphasia populations. Like CIUs, IUs are described as intelligible and informative words or phrases conveying information about a story that is both accurate and relevant, but supposedly this method uses a simpler technique for scoring. “Main event analysis” is another informativeness measure and studies that developed and used it concluded that individuals with aphasia produce fewer main events in their narratives when compared with controls (Linnik et al., 2016). Additionally, Marini and colleagues used a similar technique comprised of thematic units (an idea or detail accurate and consistent with the story) to measure informativeness (Andreetta, Cantagallo, & Marini, 2012; Marini et al., 2011). They compared performance of impaired speakers with average performance of healthy controls for this measure, as well as another measure of informativeness called “count of lexical information units” (LIUs). LIUs is a count of well formed, pragmatically and grammatically appropriate content and function words contributing to the narrative. This count of LIUs is divided by the total number of words produced, yielding a “percentage of lexical informativeness”. They concluded that speakers with aphasia generated as many main events as healthy speakers, but they demonstrated a reduced percentage of LIUs due the production of a high number of tangential and uninformative words (Andreetta & Marini, 2014; Andreetta & Marini, 2015; Andreetta et al., 2012).

Discourse structure refers to the concept that discourse has a purposeful internal organization designed to create a coherent message for a listener (Linnik et al., 2016). Information transmitted through discourse is not randomly assembled but put together in a logical sequence which makes it easier for the listener to follow. Theoretically, discourse structure is considered from two different dimensions- microstructure and macrostructure. Van Dijk (1976, 1980) created the term “macrostructure” and described it as the “topic”, “theme”, or “gist” which best represents the overall meaning or message. He created another term, “superstructure” referring to the overall structure of the narrative and its elements, for example the setting of the story, action, and conclusion (as cited in Linnik et al., 2016, p. 772). There has been no single approach to studying the macrostructure of discourse. It is not clear what aspects of discourse are responsible for creating macrostructure, and further research is needed to understand where problems with lower levels of language production begin to affect macrostructure (Linnik et al., 2016).

People with communication deficits sometimes make errors in the structure of the discourse and analyzing these errors would be considering the deficit from a structuralist/quantitative point of view, using quantitative analysis (Marini et al., 2011). Discourse is complex and made up of phonological, lexical, and grammatical processes. **Microlinguistic processing** refers to a concept of language faculties that are within-utterance and responsible for bringing all the parts of a sentence together (Marini et al, 2011). Microlinguistic processing organizes phonological and graphemic patterns into words and determines the syntax and morphological requirements for the words in a sentence. Some examples of microlinguistic variables include words per minute, mean length of utterance, morphological errors, phonemic and verbal paraphasias, grammatical errors, and articulation errors.

The opposite approach to discourse analysis would be a functionalist/qualitative approach, examining how well the speaker is able to produce information (refer back to **informativeness**) and communicate a message clearly and effectively (Marini et al., 2011). **Macrolinguistic processing** refers to a concept of language faculties that are responsible for the relationship between utterances and how they connect. Macrolinguistic processes are responsible for deciding the contextually appropriate meaning for a word or utterance (pragmatic skill) and connects them by generating the appropriate cohesive and coherent ties to create the main theme of the narrative discourse and integrate all its elements so that it best makes sense to a listener.

Cohesion in discourse refers to the semantic connectedness between units, linked via grammatical or lexical references (Halliday & Hassan, 1976). It is the connectedness of sentences, bridged where one reference in the discourse relies on the listener's understanding of and ability to reference a previously discussed idea or topic. When analyzing cohesion, one must consider the cohesive tie, or relation between the cohesive element itself as well as that which it references (Halliday & Hassan, 1976, p. 329). A word is coded as a cohesive tie if its meaning cannot be fully interpreted without reference to some other preceding explanation in the discourse (Barker et al., 2017). Cohesive ties establish meaning across the text using these grammatical and lexical references (Marini et al., 2011) A text can have accurate cohesive ties without conveying coherent meaning (Barker, et al., 2017). The following is an example of cohesively linked sentences in the absence of a coherent message: The dog ran up the *tree*/ *Tree* rhymes with *glee*/ *Glee* is my favorite television show. These sentences relate to each other and demonstrate cohesive elements, without carrying an overall message or theme. Errors in cohesion may represent a deficit in lexical retrieval (a microlinguistic process; Halliday & Hasan, 1976). Therefore, the construct of cohesion lies somewhere between the two processes, connecting microlinguistic and macrolinguistic levels of discourse (Linnik et al., 2016).

Coherence in discourse has been defined as a speaker's ability to maintain a topic supporting a unified theme (Ellis, Henderson, Wright, & Rogalski, 2016). This process is dependent on discourse systems that generate a preverbal message containing what ideas should be present to convey an accurate meaning, while also rejecting competing ideas that are related but maybe tangential or otherwise less effective at communicating a message. A sample of discourse would be considered cohesive if the units of meaning are tied together but can only be coherent if the sum of the units creates a unified and clear message (Barker et al., 2017).

Coherence can be divided into two types: local and global (Barker et al., 2017). Local coherence is also a macrolinguistic skill referring to how well each proposition (or sentence) relates conceptually to the preceding proposition (Coelho & Flewellyn, 2003). Local coherence is interrupted when the speaker interjects an abrupt change of topic and leaves a previous thought unfinished, or when the speaker uses a cohesive reference tie that is missing or erroneous (Marini et al., 2011).

Global coherence is a macrolinguistic skill referring to how well each proposition or unit of discourse relates to the overall theme or message of the discourse (Ellis et al., 2016). It represents the speaker's overarching goal for the discourse message and the execution of the conceptual organization to communicate that message. Global coherence is interrupted when the speaker produces an utterance that is tangential, repetitive or irrelevant to the story, produces new information that is related to the story but incorrect, or produces a filler utterance that distracts from the discourse task while they think of what to say next (Barker et al., 2017). Global coherence has been studied more than local coherence for both normal and impaired populations (Ellis et al., 2016).

Most studies that have examined global coherence have measured it by either a rating scale or an error count (Ellis et al., 2016). Originally a subjective five-point rating scale was used, and a mean score and percent coherence calculated by Glosser and Deser (1990 & 1992; as cited by Ellis et al., 2016, p. 360). Later, other researchers adapted this method to use a simpler three-point rating scale: low coherence given a rating of 1, medium a rating of 2, and high coherence assigned a rating of 3 (Ellis et al., 2016). As time passed, other researchers continued to use a three-point scale but adapted it and used their own criteria for assigning the ratings. Most recently, a four-point scale was also developed. Despite variance in the rating scales used, all scales included a mean score for each participant and defined a numerical range for classifying each speaker's discourse from having poor global coherence to good global coherence.

Alternatively, global coherence has also been measured using error count (Ellis et al., 2016). An error count may include frequency and type of coherence error. Marini and colleagues (2005; 2011; 2014) opted to measure the percentage of utterances including global coherence errors (classified as a tangential or conceptually incongruent utterance). Regardless of type of error count used, a higher count of errors suggests poorer global coherence maintenance of a speaker (Ellis et al., 2016).

Linnik and colleagues (2016) point out some key factors to consider when using an error count method vs. a rating scale for measuring cohesion and coherence. Because the existing rating scales have been adjusted and recreated several times depending on the study, they may represent different constructs, creating issues with construct and convergent validity. This makes it difficult to compare conclusions across studies in regard to coherence and cohesion. Conversely, a well-tested error-based technique is more reliable, but one risks losing part of the communicative intent behind discourse. When you examine discourse based on a transcription, you lose the natural communication setting where extralinguistic features (for example- gesture, facial expression, prosody or intonation, or shared common knowledge between two people) may assist in delivering the message. These considerations have been shown to influence a listener's perception of discourse, making messages that are otherwise linguistically limited or that have poor cohesion and coherence, well understood in the context of the communication exchange. Of all the methods of analysis available for measuring discourse, only perception-based measures like rating scales which require a person to subjectively consider the whole discourse sample have the potential to include extralinguistic communicative content (Linnik et al., 2016).

Applying these constructs, **informativeness, discourse structure, microlinguistic structure, macrolinguistic structure, cohesion, and coherence** results in a multilevel approach that better captures the complex interplay between levels of discourse (Linnik et al., 2016; Andreetta & Marini 2015; Marini, 2011). A variety of multilevel approaches have been suggested (Linnik et al., 2016; Andreetta & Marini 2015, Ellis et al., 2005). Marini and colleagues adapted their multilevel technique used with other populations of abnormal discourse (e.g., Schizophrenia, dementia, etc.) to be used specifically with aphasia populations (Andreetta & Marini, 2015; Marini et al., 2011). This multilevel technique incorporates both micro- and macrolinguistic skill assessment. Multilevel analysis provides a more complete picture of discourse because it accounts for the interrelatedness of discourse processes at different levels (Linnik et al., 2016). However, it is worth noting that although a multilevel analysis paints a more detailed picture, the boundaries of the constructs being assessed are sometimes ambiguous. It is often difficult to determine whether a correlation between two or more measures is proving an association between the two cognitive linguistic processes, or a correlation is instead showing that the measures are analyzing the same construct, rendering the correlations arbitrary.

Discourse has traditionally been elicited using single-picture description, sequential pictures, procedural discourse (retelling of a step by step instruction), story retelling, and recounting of subjective experiences. There are pros and cons to each type of stimulus used, depending on the intent when analyzing the sample. It is important to note that certain linguistic processes (such as syntax and vocabulary diversity) are sensitive to the type of stimulus that elicits the discourse (Kong, 2016). For example, Wright and colleagues (2014) found that quality of global coherence produced was sensitive to the type of elicitation task, probably because of the difference in cognitive demands required for each task (as cited in Ellis et al., 2016, p. 366). Many studies use picture description as the prompt to elicit a discourse sample, the most popular being a cookie theft picture from the Boston Diagnostic Aphasia Exam or a picnic scene picture from the Western Aphasia Battery (Kong, 2016). This is beneficial in some cases because the researcher can reference the picture to better understand targets of the discourse, and it also guarantees some comparability across discourse samples (Linnik et al., 2016). It has been pointed out that discourse produced in response to picture description is not ideal for discourse analysis because this task does not require the use of coherence. Story telling provides optimal content for the analysis of cohesion and coherence of language (Kong, 2016). Additionally, it was noted that there is a difference in discourse produced depending on severity of aphasia for narrative discourse but not picture description (Linnik et al., 2016). Procedural discourse and personal narratives are ideal tasks for analyzing discourse production because they provide a diverse demonstration of linguistic and extralinguistic skills, and they are tasks that are more functionally relevant for the communication challenges of everyday living. However, procedural discourse and personal narratives are relatively unconstrained and can make the identification of a lexical target and/or error difficult. An alternative would be story retelling without picture stimuli, where the target is somewhat constrained by the themes in the narrative (Kong, 2016).

II. Review of the Current Literature

Most research on discourse analysis on stroke populations has been done on individuals with a diagnosis of chronic aphasia. An important consideration underlying discourse analysis in aphasia is that standardized assessment batteries are in some cases not sensitive enough to capture recovery of language impairments (Marini et al., 2011). Larfeuil and Le Dorze analyzed the discourse recovery patterns of a cohort of 17 persons with aphasia (PWA) (1997). This cohort was 17 weeks post onset of stroke at the first time point when they performed a picture description task for analysis, then received language stimulation therapy for 6 weeks, then completed a second picture description task for analysis as well as a standardized aphasia test. Though the standardized aphasia test was unable to show improvement after therapy, the participants showed improvement in discourse, i.e. "communicative effectiveness", measured by a count of open class words produced per time unit. Another study by Helm-Estabrooks and Ramsberger (1986) was also able to show recovery by using a multi-level analysis for morpho-syntactic skills following a treatment targeting syntax for a group of people with chronic agrammatic aphasia (as cited in Marini et al., 2011, p. 1373). Another study (Marini, Caltagirone, Pasqualetti, & Carlomagno, 2007) used multivariate analysis showed that three individuals with non-fluent aphasia were able to increase the informativeness of their language samples following treatment, whereas results of a standard aphasia test only showed minimal improvements (as cited in Marini et al., 2011, p. 1373). This difference in informativeness was even subjectively observed by non-expert judges. Recently, Fromme, Forbes, Holland, Dalton, Richardson, and MacWhinney (2017) examined a population of individuals whose score on the Western Aphasia Battery and on the Western Aphasia Battery-Revised did not qualify them as "aphasic", however they still reported deficits in their communication abilities. This population needs careful consideration because although they are technically not considered "aphasic" as designated by these standardized batteries, they clearly report that their language abilities are abnormal to them since their stroke and have not recovered. Results from this study concluded that by using multilevel discourse analysis, it is evident that this special population does indeed experience narrative discourse deficits in comparison with healthy controls. This supports the need for multilevel assessment, examining both structural and functional linguistic processing, when examining discourse for patterns of recovery (Marini et al., 2011; Sherratt, 2007).

Data thus far have created a confusing, contrastive picture of discourse for chronic aphasia populations in regards to which skills are left intact and which are not. Researchers have speculated about how microlinguistic and macrolinguistic deficits present in PWA. Earlier studies by Ulatowska and colleagues have established that although the narratives of their participants with aphasia were shorter and grammatically simpler, they still contained essential elements of story grammar and the correct order of events demonstrated (Linnik et al., 2016, p. 767). These reports suggest intact macrostructure with simultaneous microlinguistic deficits for PWA. Further research by Armstrong & Ulatowska (2007), Glosser & Deser (1991), Gordon (2006), and Ulatowska et al. (2003) has seemed to confirm that aphasic speakers as a group tend to demonstrate overall preserved macrostructure, global coherence, and pragmatic skills (as cited in Linnik et al., 2016, p.767). In contrast to the above studies that assert macrolinguistic structure for this population, other studies by Armstrong, Ciccone, Godecke, & Kok (2011), Fergatiodis & Wright (2011), and Wright (2011b) have suggested PWA have significant difficulty communicating a message via discourse (as cited in Linnik et al., 2016, p. 767). A longitudinal study by Coehlo and Flewellyn (2003) examined the recovery of discourse of a person with fluent aphasia and concluded that microlinguistic abilities improved over time, but macrolinguistic difficulties persisted at one year post stroke. Results supporting this view assert that PWA produce excessive irrelevant proposition content, reduced efficiency, and low lexical informativeness (Andreetta, 2014; Andreetta & Marini, 2015; Nicholas & Brookshire, 1993).

In summary, the complexity of discourse suggests the need to examine the connection between micro and macrolinguistic processes, and in the same vein the relationship between aspects of local and global coherence (Linnik et al., 2016). Some researchers have claimed that despite issues with microlinguistic deficits, PWA can still use alternative means to communicate a message. Other research has asserted that the difficulties with microlinguistic processing in PWA affects global coherence of their discourse, making it less effective for communication. More recently, researchers using multilevel approaches confirmed that aphasic discourse can be characterized as having macrolinguistic impairments that are caused by reduced microlinguistic ability (Andreetta et al., 2012; Marini et al., 2011; Marini et al., 2015; Wright & Capilouto, 2012; Sherratt, 2007). Finally, there has also been research comparing left vs. right hemisphere stroke, and how side of lesion location affects discourse production. Karaduman, Gökson, and Chatterjee (2017) tested 36 unilateral stroke survivors and determined that both hemispheres are necessary for adequate narrative production with left hemisphere stroke participants demonstrating deficits in microlinguistic skills, and right hemisphere stroke participants demonstrating deficits in macrolinguistic skills due to a lack of planning and working memory ability needed to relate events of the narrative together.

Linnik and colleagues (2016) offer an explanation for the source of contradictions in the research. They speculate that one cause is likely inconsistencies in the definitions of terms across studies and differences in methodologies used to assess the same constructs. They go on to say that using different methodologies to approach discourse analysis, depending on the constructs assessed, make different demands on the discourse of the speaker, potentially providing access to different cognitive abilities in the participants (Linnik et al., 2016).

With respect to the current literature covering discourse recovery, very few studies have examined recovery from an acute time point. Ellis, Rosenbek, Rittman, and Boylstein (2005) investigated cohesion in the narrative discourse of 12 left hemisphere stroke patients with no aphasia diagnosis at three time points: one month post stroke, six months, and 12 months. They counted cohesive ties and concluded that the mean number of total cohesive ties used by each participant remained generally constant from one month to one year post onset, but the percentage of correct cohesive ties improved significantly from one month to one year post onset. This study suggested that subtle disruptions in the form of cohesive errors in narrative discourse may be present at onset, but accuracy improved naturally with time for this cohort (Ellis et al., 2005).

III. Current Study

The goal for this project was to establish the degree to which participants diagnosed with acute left hemisphere stroke demonstrate microlinguistic and macrolinguistic deficits in discourse production. We used multivariate analysis (Marini et al., 2011) to determine the degree to which 16 stroke patients with a range of language deficits exhibited micro or macro deficits in comparison to neurotypical controls. We analyzed their discourse production at two time points, acutely (within one week of stroke) and sub-acutely (within 3 months following stroke) to investigate how deficits changed over time as reorganization occurs following stroke. Several studies have examined longitudinal recovery of discourse deficits (e.g., Coehlo & Flewellyn 2003; Ellis, 2005). Cohesion has been studied longitudinally for recovery of 20 patients with left hemisphere stroke. Results indicated that although participants used the same mean amount of cohesive ties at one month post stroke and after twelve months of recovery, they showed a greater percentage of accurate use of cohesive ties from 1 month to 12 months (Ellis, 2005). Coehlo and Flewellyn (2003) examined the discourse recovery of one patient with aphasia longitudinally, but the aim of the study were results following a specific type of treatment.

Narrative discourse after stroke without presence of diagnosed aphasia is an understudied population when it comes to communication deficits (Ellis et al., 2005). To our knowledge, our study will be the first to examine if and how discourse changes from the acute to subacute phase as reorganization occurs after left hemisphere stroke.

The purpose of this study was to examine whether a population of individuals with acute left hemisphere stroke experienced deficits in discourse, and whether they improved over time. We hypothesized that a population of individuals with acute left hemisphere stroke would have varying degrees of deficits in cohesion and coherence based on previous evidence from persons with chronic left and right hemisphere stroke (Barker et al., 2017). For participants who exhibited impairments in microlinguistic skills, then we hypothesized macrolinguistic deficits would also have a related impact on their narrative (Andreetta & Marini 2015; Wright & Capilouto 2012). If macrolinguistic deficits are indeed related to microlinguistic deficits for this population, then as participants recovered from the acute to subacute stage of stroke, we predicted correlations of recovery for both macro and microlinguistic skills. This project provided information concerning the incidence of discourse impairments in individuals in the acute stage of stroke and how discourse changed in the initial stages post stroke. It is important to investigate the prevalence of discourse impairment in acute stroke to better understand whether this patient group requires rehabilitation in communication.

IV. Hypotheses and Predictions

1. In our population of left hemisphere acute stroke, what is the incidence of communication deficits in comparison to healthy controls?
    a. We hypothesized that a population of individuals with acute left hemisphere stroke will have varying degrees of deficits in microlinguistic abilities as well as cohesion and coherence based on previous evidence from persons with chronic left and right hemisphere stroke (Barker et al., 2017).
2. Are macrolinguistic deficits related to microlinguistic deficits, as shown in populations with aphasia diagnoses?

a. If macrolinguistic deficits are related to microlinguistic deficits, then we expect to see this relationship acutely and recovery should show correlated changes from acute (within 1 month) to subacute (within 3 months) time points.

Survivors of chronic stroke may demonstrate communication impairments in discourse (specifically, cohesion and coherence) without obvious symptoms of aphasia (Barker et al., 2017). The incidence of discourse impairments in individuals in the acute stage of stroke is less well understood. There may be potential relationships between micro and macro aspects of discourse for our population, as has been shown in aphasia populations. If this is true, those relationships would be observable at the acute time point and potentially at the sub-acute time point for our sample.

If microlinguistic deficits are related to macrolinguistic deficits for our population, then our results would be expected to follow patterns established in the literature to date. However, it should be noted that these predictions were largely based upon studies in which the participants were patients with diagnosed chronic aphasia (Andreetta et al., 2012; Marini et al., 2011; Marini et al., 2015; Wright & Capilouto, 2012; Sherratt, 2007). Our cohort is quite different. The hallmark of chronic aphasia is a deficit in word finding (Kong, 2016, p. 5). Because our cohort is acute stroke without evaluation for aphasia, the incidence of word finding deficits (or proportion of correct picture naming) may be less prevalent for our population. As a result, it is less clear that we should find the same patterns as what has been found in chronic stroke data.

In reference to our hypothesis about microlinguistic variables being related to macrolinguistic variables in discourse, we expected the primary variable of lexical retrieval as measured by percent accuracy on our picture naming task to be the focus of predicted correlations. When correlations in aphasia literature showed a relationship between syntax or phonological processing and a macrolinguistic measure, this relationship seemed to have been caused by an underlying deficit of lexical retrieval processing (Andreetta & Marini, 2015; Andreetta et al., 2012). If a patient cannot lexically retrieve a target word, it follows that they will be unable to retrieve the associated morphological forms of that target, nor will they be able to access the motor planning schema to accurately produce the phonemes of the target word. Lexical retrieval deficit would be an underlying cause of a patient's inability to produce correct syntax or an accurate phonological production.

When considering the microlinguistic variable of **lexical retrieval,** we predicted that percentage of naming accuracy would correlate with **cohesion** because a speaker who has a lexical retrieval deficit may also demonstrate an overdependency on non-specified nouns or noun substitutes (aka, incorrect or ambiguous referents). Additionally, we predicted that percentage of naming accuracy would correlate with **local coherence** because a speaker who has a lexical retrieval deficit will also likely have frequent errors in local coherence. Their speech would contain missing referents, and abrupt topic switches from one thought to another if the speaker cannot retrieve a target word. We predicted that percentage of naming accuracy would correlate with **global coherence** as well, because a speaker who has lexical retrieval deficits will likely use frequent fillers, repetitive information, and tangential information as a delay tactic while they try to come up with the word they are looking for. Percentage of naming accuracy might also inherently have correlated with **content information units,** as this is a macrolinguistic variable which depends on naming accuracy). Lastly, percentage of accuracy on naming should not have correlated with **% of thematic selection**; we predicted that some speakers may still be able to select main ideas or the themes of a narrative and convey them, despite a deficit in lexical retrieval. To summarize, for subjects that had a deficit in lexical retrieval, we predicted to see a correlation of percentage of naming accuracy with every macrolinguistic dependent variable, with the exception of percentage of thematic selections.

V. Methods

Subjects

We analyzed speech data from 17 subjects within three days (median = 3 days, range 2 – 7 days) of admission to one of three comprehensive stroke units in the Texas Medical Center, Houston Texas (Houston Methodist Hospital, Baylor St. Luke's Hospital, and UT Health Science Center Memorial Hermann Hospital). Inclusion criteria included that s/he suffered a left hemisphere cerebrovascular accident in the preceding 72 hours, was a native monolingual speaker of English, had sufficient cognitive and language function to understand task instructions, was between 18 and 85 years of age, could verbally consent or indicate that a family member could consent for them. Subjects had no previous history of symptomatic neurological disorder that introduced a separate cause of language or cognitive deficits apart from the stroke and no significant sensory deficits that rendered them unable to follow task instructions or see task items to be named. We tested subjects a second time one to three months later (median = 40 days, range 23 – 91 days) at the Baylor College of Medicine, Houston, Texas. Average age at time of testing was 61 years (median = 60 years, range 33-85 years) and average years of education was 14.5 years (median = 13 years, range 12 – 20 years; one subject did not report their education level). One subject's speech narrative could not be analyzed because of disruptions at hospital bedside (s38). We analyzed discourse in a group of 14 age- and education- matched controls (median age = 55.5 years, range = 37 – 78 years; median years education = 16 years, range = 12- 22 years). Informed consent was obtained from either the subject or a legally authorized representative of the subject as approved by the institutional review boards of Baylor College of Medicine, Rice University, the University of Texas Health Science Center, and the Houston Methodist Hospital.

Design

Subjects recounted the Cinderella story after viewing the picture-book "Cinderella" (Jeffers, 2004) with the text occluded. Subjects took as long as they needed viewing the modified picture-book, but subsequently retold the tale without visual aid. We asked subjects to be as descriptive as possible and use full sentences. If subjects did not produce an adequate number of words, the experimenter prompted subjects to continue speaking, typically by asking the subjects to elaborate further.

We attempted to use utterance boundaries segmented according using acoustic, semantic, grammatical, and phonological criteria (see Marini et al., 2011). Utterances were first determined by acoustic criteria, defined as easily identifiable pauses in the flow of speech. If there were no pauses, then utterances were determined by semantic criterion, or more specifically when a proposition has been fully completed and a new proposition introduced. If neither of these methods distinguished the boundaries of an utterance, then the boundaries were determined using grammatical criteria. The utterance was considered complete if it formed a grammatically complete sentence. Lastly, phonological criteria for defining utterance boundaries included when there is a false start followed by a change in topic or phonological interruption to a word or idea. We attempted to use this method initially, but when training a second scorer for reliability to use this method, it was difficult to achieve high reliability. Instead the original method of segmentation was abandoned and a method with strict rule-based criteria, C-Unit segmentation and conventions from SALT Software were used to segment all utterances (Miller, Andriacchi, & Nockerts, 2011). This method proved to be reliable when used with a second scorer.

To measure whether a participant with stroke significantly differed on a measure of discourse in comparison to controls, we used Bayesian inferential statistics as described by Crawford, Garthwaite, and Porter (2011; see also Crawford and Garthwaite, 2007).

Microlinguistic Analysis

Following the multivariate analysis outlined by Marini and colleagues (2011), we included several components of microlinguistic analysis based on narrative discourse processing, including measures of *productivity, lexical processing,* and *grammatical processing* (see Table 1 for summary). A unit count of all verbalizations (including intelligible neologisms) was calculated first and not used as a measure of change but as denominator to express measurement. *Productivity* of each sample refers to a measure of general output which included a word count of all phonologically well-formed words including suspected verbal paraphasias, a total number of utterances per story**,** and a speech rate calculated in well-formed words per minute (Marini et al, 2011; Sherratt 2007). As a measure of *lexical processing*, we used percentage correct during picture confrontation naming (47 items)[1]. As a measure of phonological processing we used a proportion of well-produced words (a measure of phonological output skills) over the total number of units. For *grammatical processing*, we used percentage of grammatically complete sentences (only sentences with correct grammar are counted as intact grammatical processing) over the total number of utterances.

As our *lexical processing* measure, we administered several confrontation naming tasks as part of a larger test battery administered at hospital bed side and at follow-up. Confrontation naming included two different sets of pictures. Seventeen items administered in other acute populations (e.g., Hillis & Heidler, 2002; Cloutman, Newhart, Davis, Kannan, & Hillis, 2010; Hillis et al., 2006) and a separate list of items which varied in name agreement (n=30). Items were depicted by photographs chosen from the BOSS naming stimuli

[1]Marini and colleages (2011) measured lexical processing from the narrative generated from a series of presented pictures. Thus, Marini and colleagues were able to judge whether the word produced matched the target. However, because we used a narrative story retell for our discourse elicitation task, it is difficult to judge occurrence of a semantic or verbal paraphasias because the target is ambiguous and unpredictable when participants are generating their own narrative without an external stimulus for coreference with the listener.

(O'Sullivan, Lepage, Bouras, Montreuil, & Brodeur, 2012). Naming items including lexical frequency, length, and number of syllables is presented in Appendix A. Because subjects were tested at hospital bedside, test administration was sometimes halted out of necessity for a variety of reasons (e.g., clinical testing, patient visitors, fatigue etc.). As a result, of the 16 subjects included in analyses, 15 subjects had the opportunity to name 47 items, and one subject had the opportunity to name 30 items. General performance (e.g., average, minimum, maximum) on naming and discourse variables is presented in Appendix B.

Table 1. Microlinguistic analysis.

Baseline Measures of Productivity	***Definition of the Terms***
Word Count	Count of all phonologically well-formed words *only recognizable produced phonemes in the correct order add
Unit Count	Count of all verbalizations recorded as part of the narrative, including word that are unintelligible and phonologically ill-formed
Utterance Count	Total number of utterances produced per narrative
Speech Rate	Word count divided by time from beginning to end of narrative; i.e. words per minute
Microlinguistic Processing Measures	
Picture Confrontation Naming Accuracy	Proportion of correctly named picture stimuli
Proportion of Well Produced Words	Word count divided by unit count
Percentage of Grammatically Complete Utterances	Percentage of grammatically complete utterance expressed as a ratio in comparison to utterance count (A sentence must include a subject and a verb or verb phrase, grammar must be fully intact)

***Table 1. The above measures are considered dependent variables as a measure of microlinguistic processing*.**

In summary, microlinguistic analysis included seven measures: four measures of productivity (a unit count of verbalizations, word count, number of utterances per story, and speech rate), one measure of lexical processing (picture confrontation naming accuracy), one measure of grammatical processing (percentage of grammatically complete sentences), and one measure of phonological processing (proportion of well-produced words). Subjects had a deficit in microlinguistic skill if they performed significantly below controls on any of these seven measures.

Macrolinguistic Analysis

Macrolinguistic skills are comprised of two levels of narrative discourse processing, **informativeness** and **narrative organization** (Marini et al., 2011). **Informativeness** refers to the information content of a narrative (Marini et al., 2011). To capture informativeness, we calculated two measures: *percentage of content information units* and *percentage of thematic selection. Percentage of content information units* refers to a measure of appropriate lexical content and is calculated by counting the total content and function words that are phonologically correct, divided by the total number of words produced. Semantic and verbal paraphasias (to the extent we could determine these from the spontaneous narratives), lexical fillers, repetitions, words with incorrect morphology, without clear referents, or all words included in a tangential or conceptually incongruent utterance are excluded from this count (Andreetta, Marini 2015). *Percentage of thematic selections* is an index of the amount of novel informational propositions the speaker can produce in relation to the stimuli (Marini et al., 2011). It was scored in comparison with data from *the Aphasia Bank*, where researchers derived a list of main concepts for the Cinderella narrative (Richard & Dalton, 2015). Richard and Dalton (2015) identified 34 main concepts from a sample of 92 controls. Only propositions included by 33% or more of the participants were included as a main concept (Richard & Dalton, 2015). We used these data as a baseline for main concepts because it was derived from a larger pool of participants than our own control population. The calculation was done by dividing the number of thematic units produced for the story by the total number of correct thematic units (34), multiplied by 100.

Narrative organization is made up of four different measures (*cohesive error score, cohesive correct score, local coherence,* and *global coherence)*, referring to how well the information provided is organized and related to the overall topic. Cohesion (which consists of the *cohesive error score* and the *cohesive correct score*) refers to the structural and lexical connectivity of contiguous utterances (Andreetta and Marini, 2015). According to the classification system developed by Haliday and Hassan (1976), cohesive errors include the misuse of cohesive ties, such as errors in pronoun agreement, incorrect reference of lexical content words, interruption of utterances, or misuse of conjunctive ties (see Table 2 for summary). Marini and colleagues (2012, 2015) also introduced the aposiopesis error type to cohesion in their multilevel analysis, which was relevant for our subjects and therefore included in this study. For best comparability with previous studies

(Barker et al., 2017, Ellis et al., 2005), we analyzed cohesion by calculating a cohesive error score. The cohesive error score was calculated by counting total reference errors and total conjunctive errors. Each measure was expressed as a percentage of total cohesive ties attempted. We did not analyze lexical ties because we could not be certain of the lexical referent within the narrative discourse, and others have found it not to be informative (Barker, 2017; Andreetta & Marini, 2015).

Table 2. Examples of cohesion errors.

Types of Cohesion Errors	***Subtypes***	***Examples***
Reference- A word which cannot be interpreted semantically in isolation but requires a reference to preceding discourse to fully understand its meaning	**Personal** reference includes personal pronouns and determiners such as she, her, they, etc.	Cinderella went home// and then **she** turned back to her original way//
	Demonstrative reference is a verbal equivalent of pointing within the narrative. The speaker makes reference to preceding discourse and clarifies a location or proximity from the referent. using determiners such as that, there, this, where, these, those, etc.	The mom and sisters are in attendance// and they're not very happy about all of **that**//
	Comparative reference is a personal pronoun or determiner which points out similarity or dissimilarity between two or more narrative details.	He's not even paying attention to the mom or the daughters// **they're** chopped liver to him//
Conjunction- A word which specifies the way in which the utterance following it was connected to the previous idea.	**Additive** conjunctions add new examples, information, or support a previous statement. Common examples include the following: or, and, for instance, for example, further, also, likewise, etc.	He's not even paying attention to the mom//**or** the daughters//
	Adversative conjunctions adds contrasting information to the current idea or utterance and includes the following: yet, but, however, in fact, on the other hand, instead, rather, anyhow, in any case, unfortunately.	She's dressed appropriately to go// **but** the stipulation is she has to be home by midnight//
	Causal conjunctions indicate a consequence resulting from a preceding action. Common	He knows that she's the girl//and **so** he takes her//

	examples include: so, because, therefore, consequently, in order to, etc. **Temporal** conjunctions indicate a shift in time or reference previously stated events in the story. Common examples include: then, before, the next thing you know, by that time, the next day, never, ends, soon, soon to be, as, by, etc.	 Maybe she could be his future bride instead of those stepsisters// **then** the story shifts to the ball//
Aposiopesis- a condition of the speaker returning to and completing an abandoned previous thought, wherein otherwise a topic shift would occur.		She went to her….//no, not her father but the fairy//

Table 2. Definitions and examples of the categories of cohesive ties, modified from Halliday and Hasan (1976) – (Modified from Barker et al., 2017, p. 34; Andreetta & Marini, 2014, p. 76).

Local coherence was measured as a percentage of local coherence errors, measured by counting local coherence errors (abrupt changes of topic and missing referents) then dividing that number by the number of total utterances produced and multiplying that value by 100 to get the total percentage of local coherence errors (Marini et al., 2011). We included the proportion of local coherence errors as a measure of how well each utterance is conceptually related to the preceding one (Marini et al., 2011).

Table 3. Local coherence errors.

Types of Local Coherence Errors	***Examples***
Topic switching- a sentence stops abruptly, is interrupted, or abandoned by the speaker and the discourse makes a change in topic unrelated to the abandoned utterance.	And some….// And she fell in love with a prince//
Missing referents- an error is counted when a pronoun or referent is either incorrect OR missing completely. All incorrect reference cohesion items should additionally be added to this count.	And then he found Cinderella//tried it on her//

Table 3. Definitions and examples of the categories of local coherence errors, adapted from Marini et al., 2011.

Errors of global coherence included utterances that were tangential to the topic or story line (tangential utterances, disrupting the flow in regards to information presented previously), sentences containing ideas unrelated to the task (conceptually incongruent utterance), fillers, or perseverations (repeated idea or utterance, also called a propositional repetition). This measures a speaker's ability to relate concepts semantically to the overall theme or message of a discussion. These error counts were added together to yield a global coherence error count, divided by the total number of utterances to yield an index of global coherence errors (Marini, Andreeta et al., 2011).

Table 4. Global coherence errors.

Types of Global Coherence Errors	***Examples***
Tangential utterance- interrupts the narrative by introducing an utterance which is not a contribution to the narrative or is unrelated to the previous utterance.	Cinderella was running away and she dropped her glass slipper// **It always astounded me how a glass slipper could be comfortable**//
Conceptually Incongruent utterance- introduces information that is unrelated and does not belong in any version of the narrative	The big sisters were there// **And they all went to the game**//
Propositional repetition- Information which has already been stated and does not contribute new content to the narrative	She went to a ball// **And then she went to the ball**//
Filler utterance- an utterance that does not contribute to the narrative task or carry information. It may represent a way to fill time while the speaker processes what has been said and thinks of what to say next.	And she gave her a gorgeous gown// **and all that stuff//**

Table 4. Definitions and examples of the categories of local coherence errors, adapted from Marini et al., 2011.

In total, there were six measures of macrolinguistic structure: percentage of lexical informativeness, percentage of thematic selections, cohesive error score, cohesive correct score, local coherence, and global coherence. We evaluated subjects as having a deficit in macrolinguistic skill if they performed significantly worse than controls on any of these six measures.

Table 5. Summary of macrolinguistic analysis variables.

Levels of Informativeness	*Definition of the Terms*
Content Information Units	Total number of content and function words in the Word Count that are and pragmatically appropriate (minus filler utterances and unidentifiable verbal paraphasias), divided by the Word Count
Percentage of Thematic Selections	Number of thematic units produced by the total number of correct thematic units produced by controls (34, Richardson & Dalton, 2015)
Narrative Organization	
Cohesive Error score	Total number of error reference ties plus total number of error of conjunctive ties, expressed as percentage of total cohesive ties
Local Coherence	Count of local coherence errors divided by total utterances
Global Coherence	Total number of global coherence errors divided by total utterances

***Table 5. The above measures are the 6 total dependent variables considered as a measure of microlinguistic processing*.**

Statistical Analysis

We compared single subject performance with control group performance according to methods outlined by Crawford and Garthwaite (2007).

VI. Results

Reliability

A second rater independently transcribed and scored 20% of randomly selected samples from among the controls and patients. Both raters were blinded to the indent of the samples (subjects versus controls) and the time point, s and completed the analyses independently. A third rater compared the results of the two transcriptions to resolve any differences before the next phase of analysis was initiated to eliminate the impact of a transcription or segmentation error on the error analyses (see Table 6). Results were compared at each stage of analysis for each sample. This included utterance segmentation, unit count, word count, and coding of each sample to count number of grammatical utterances, number and identity of themes included, total number of correct cohesive ties, total number of cohesive errors, total local coherence errors, total global coherence errors, and total CIU's. The degree of point-to-point agreement is represented as a percentage between the narrative word count of the two listeners, the identity of the words, the number of utterances segmented, and the coding or count of each variable.

For all measures, inter-rater reliability was acceptable to high, ranging from 84% agreement on utterance segmentation (utterance count) to 96% on the transcription content, suggesting the different discourse elements were classified and coded accurately.

Table 6: Point to point inter-rater reliability for narrative transcription, segmentation, and error coding.

Inter-Rater Reliability of Discourse Measures	
Discourse measure	**% Inter-rater agreement**
Unit Count (Identity and number of words)	96%
Utterance Count Agreement	84%
Word Count Agreement	97%
Grammatically Complete Utterances	93%
Cohesion	88%
Local Coherence Errors	94%
Global Coherence Errors	91%
Number of Themes	86%
CIU Count	92%

Acute Sample

Upon examining the data of the acute sample in comparison with controls for microlinguistic variables, we found that a total of eight subjects from the acute sample demonstrated some type of microlinguistic deficit in comparison to controls according to their scores on microlinguistic measures of words per minute, proportion of correct pictures named, percentage of grammatically produced utterances, and proportion of phonologically well-formed words (see Table 7). Five of sixteen acute subjects exhibited problems with picture naming. For phonologically well-formed words, five out of sixteen acute subjects also had deficits. Five of sixteen subjects produced significantly fewer words per minute than control subjects. Three out of sixteen acute subjects demonstrated issues with producing correct grammatical structures.

Table 7. Results for each subject at the acute time point for microlinguistic variables, including min, max, and mean.

Microlinguistic Results: Acute Time Point				
Acute Subject #	**Picture Naming**	**Well Produced Words**	**Grammatically Complete Utterances**	**Words Per Minute**
s18	**0.922***	**0.929***	**0.317***	98
s19	0.681	**0.828***	**0.324***	**45***
s20	0.936	0.983	0.694	110
s21	0.909	0.993	0.774	103
s25	0.922	0.984	0.867	104
s49	0.935	0.989	1.000	140
s55	0.974	0.981	0.875	114
s78	**0.766***	**0.933***	0.630	93
s92	**0.818***	1.000	0.750	**48***
s100	0.948	0.997	0.778	122
s104	0.922	0.993	0.972	176
s109	0.896	**0.846***	0.941	**70***
s115	0.935	0.994	0.867	**75***
s126	**0.818***	0.991	0.778	96
s128	0.948	0.997	0.958	120
s129	**0.067***	**0.754***	**0.269***	**21***
MIN	**0.067**	**0.754**	**0.269**	**21.000**
MAX	**0.974**	**1.000**	**1.000**	**176.000**
MEAN	**0.837**	**0.950**	**0.737**	**95.938**

Table 7. An "*' indicates performance significantly below controls at the p < .05 level (one-tailed) as determined by Crawford and Garthwaite (2007).

In total, nine out of sixteen acute subjects exhibited some type of deficit for macrolinguistic measures of percentage of thematic selection, proportion of CIU's produced, cohesive errors, local coherence errors, and global coherence errors (see Table 8). Seven out of sixteen subjects had some type of issue with macrolinguistic informativeness measures of percentage of thematic selection and proportion of CIUs. When looking at the data of the acute sample compared with controls for macrolinguistic variables, three out of sixteen subjects demonstrated difficulty communicating the appropriate themes for the story. Six out of sixteen subjects were statistically worse than controls on proportion of CIU's produced. Nine out of sixteen had some type of narrative organization deficit (cohesion or coherence). Six out of sixteen subjects demonstrated more cohesion errors compared with controls. Four out of sixteen acute subjects demonstrated more errors in local coherence, and seven out of sixteen acute subjects demonstrated significantly more errors in global coherence. In summary, across all acute subjects, 11 out of 16 subjects scored worse than controls on some type of micro or macrolinguistic measure.

Table 8. Results for each subject at the acute time point for macrolinguistic variables, including min, max, and mean.

Macrolinguistic Results: Acute Time Point					
Acute Subject #	**Cohesive Error Score**	**Local Coherence Error Score**	**Global Coherence Error Score**	**Proportion of CIUs**	**Thematic Selection**
s18	**0.129***	**0.268***	**0.366***	**0.690***	0.324
s19	**0.456***	**0.500***	**0.206***	**0.592***	**0.147***
s20	**0.093***	0.102	**0.306***	**0.606***	0.529
s21	0.042	0.065	0.065	0.837	0.559
s25	**0.235***	**0.467***	0.000	0.917	0.618
s49	0.050	0.071	**0.214***	0.872	0.265
s55	0.083	0.063	0.000	0.845	0.324
s78	**0.196***	0.109	**0.261***	**0.649***	0.294
s92	0.000	0.000	0.000	1.000	**0.0294***
s100	0.020	0.028	0.000	0.870	0.735
s104	0.055	0.028	0.111	0.961	0.559
s109	0.068	0.029	0.088	0.979	0.618
s115	0.044	0.067	0.067	0.891	0.294
s126	0.069	0.056	**0.167***	**0.614***	0.265
s128	0.000	0.000	0.000	0.980	0.618
s129	**0.622***	**0.846***	**0.346***	**0.360***	**0.000***
MIN	**0.000**	**0.000**	**0.000**	**0.360**	**0.000**
MAX	**0.622**	**0.846**	**0.366**	**1.000**	**0.735**
MEAN	**0.135**	**0.169**	**0.137**	**0.792**	**0.386**

Table 8. An "*' indicates performance significantly below controls at the p < .05 level (one-tailed) as determined by Crawford and Garthwaite (2007).

Acute Stroke Analysis

We analyzed whether the degree to which impairment in the microlinguistic measure of picture naming accuracy was related to impairments at the macrolinguistic level (cohesion, local and global coherence, CIU's, and thematic selection) to determine whether microlinguistic impairments predict ability to communicate at the macrolinguistic level. Because we found significant correlations between different discourse measures (p's < .1; see Table 9 for pairwise correlations among the variables), we used multiple regression to test whether macrolinguistic discourse measures had a significant independent relationship with the microlinguistic naming measure after taking the other macrolinguistic measures into account. For the multiple regression, we looked for outliers using the criterion of a studentized residual greater than 2.5 and a Cook's D value greater than 2.5 times the mean Cook's D. s129 had a studentized residual of – 3.0 and a Cook's D of 2.66. Identified as an outlier, we removed s129 from analysis.

Table 9. Pair-wise correlation probabilities between macrolinguistic discourse measures at the acute time point.

Pairwise Correlations

Variable	by Variable	Correlation	Count	Lower 95%	Upper 95%	Signif Prob	-.8 -.6 -.4 -.2 0 .2 .4 .6 .8
Cohesive Error Score	Proportion of Thematic Selection	-0.5030	16	-0.7994	-0.0097	0.0470*	
Local Coherence Error Score	Proportion of Thematic Selection	-0.4305	16	-0.7633	0.0829	0.0960	
Local Coherence Error Score	Cohesive Error Score	0.9542	16	0.8701	0.9843	<.0001*	
Global Coherence Error Score	Proportion of Thematic Selection	-0.4251	16	-0.7605	0.0895	0.1007	
Global Coherence Error Score	Cohesive Error Score	0.5265	16	0.0416	0.8106	0.0362*	
Global Coherence Error Score	Local Coherence Error Score	0.4747	16	-0.0274	0.7856	0.0632	
Proportion of CIUs	Proportion of Thematic Selection	0.5062	16	0.0140	0.8009	0.0454*	
Proportion of CIUs	Cohesive Error Score	-0.7588	16	-0.9116	-0.4218	0.0007*	
Proportion of CIUs	Local Coherence Error Score	-0.6811	16	-0.8798	-0.2799	0.0037*	
Proportion of CIUs	Global Coherence Error Score	-0.7956	16	-0.9261	-0.4952	0.0002*	

Table 9. Significant p-value for correlations indicated by an *. No outliers removed.

See Table 10 (A-B) and Figure 1 (A-E) for acute results. Figure 1 (A-E) illustrates how each participant's performance in naming was dependent on their performance on the specific macrolinguistic variable, after accounting for performance from other macrolinguistic variables. The 45-degree sloped line represents what the model predicts performance should be based on the variables included. The distance from the sloped line to the data point shows how much the specific subject's performance was accounted for by the model (observed vs. predicted). The further away the data point, the less it was accounted for. The horizontal line is the average of the difference between observed data and predicted data from the model (essentially, the null hypothesis). The distance from each data point to the horizontal line represents performance without including any variables in the model. The gray area represents a 95% confidence curve. The slope of this gray area compared with the horizontal line shows a significant effect or correlation (p <.05) if the slope is large enough that there is an area of white space between the gray area of confidence and the horizontal line. Alternatively, if the horizontal line is within the gray line for the model, then that correlation was not significant (p>.05; Sall, Lehman, Stephens, & Creighton, 2012). We found that the less accurate a picture was named, the greater the proportion of cohesive errors (the coefficient for cohesive error was significant (p = .001). If a subject was worse at picture naming, then they were also more likely to be worse at generating accurate cohesive ties. Unexpectedly, we also found that the less accurate a picture was named, the *fewer* local coherence errors produced (p = .01). This correlation indicated that if a subject was worse at picture naming, then they were also more likely to have *better overall local coherence.* Only these two variables of cohesion and local coherence showed a correlation with picture naming for the acute sample. No other discourse factors predicted naming performance (p's > .29).

Table 10 (A-B). Results of multiple regression (p-values for significant beta coefficients indicated by '*').

A. Overall model.

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	5	0.08027668	0.016055	10.7829
Error	9	0.01340070	0.001489	Prob > F
C. Total	14	0.09367738		0.0014*

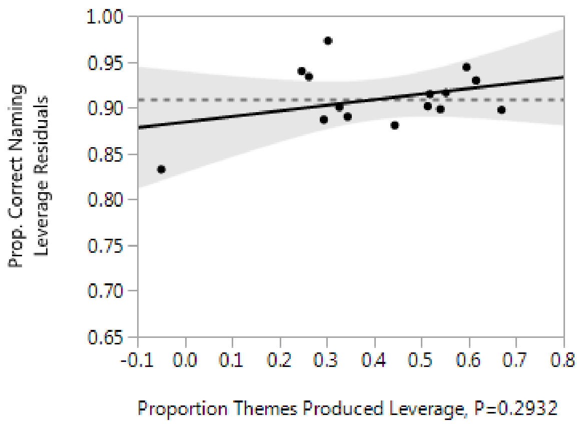
B. Discourse measures.

Parameter Estimates

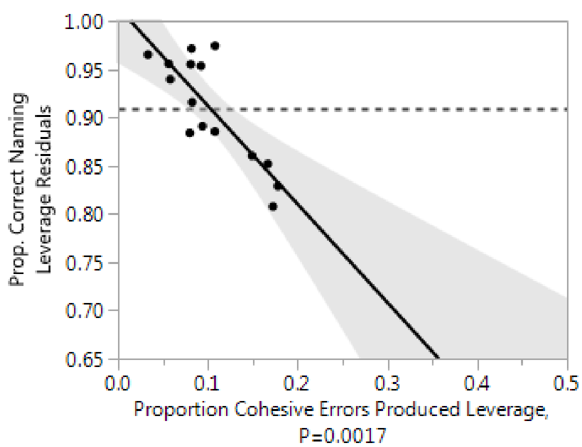
Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.8376209	0.121671	6.88	<.0001*
Proportion of Thematic Selection	0.0609141	0.054562	1.12	0.2932
Cohesive Error Score	-1.018571	0.231167	-4.41	0.0017*
Local Coherence Error Score	0.4438231	0.152583	2.91	0.0173*
Global Coherence Error Score	0.0974123	0.129302	0.75	0.4705
Proportion of CIUs	0.1029611	0.123806	0.83	0.4271

Figure 1 (A-E). Multiple regression scatterplots demonstrating the independent contributions of macrolinguistic measures to proportion of accuracy in naming.

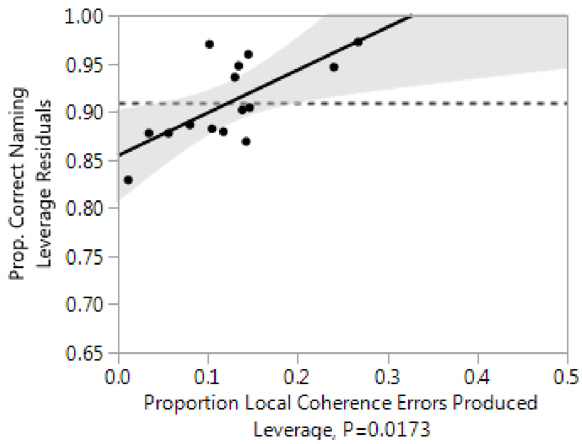
A. Proportion of thematic selection errors.



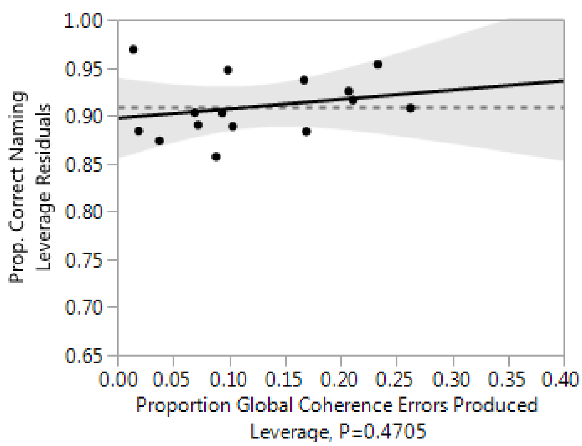
B. Proportion of cohesive errors.



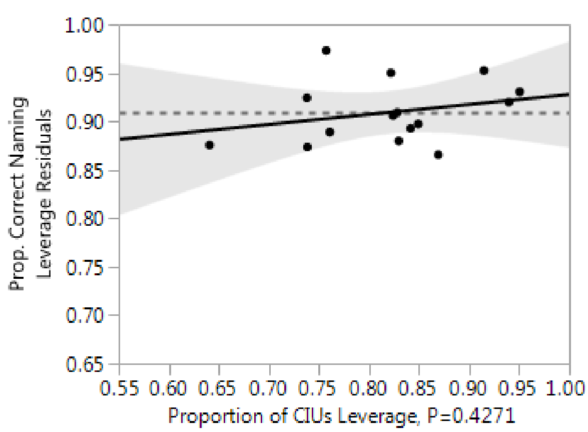
C. Proportion of local coherence errors.



D. Proportion of global coherence errors.



E. Proportion of CIUs produced.



We also compared microlinguistic picture naming results with the remaining microlinguistic variables (words per minute, grammatically correct utterances, and phonologically well-formed words) for the acute sample**.** Because we found significant correlations between the different microlinguistic discourse measures (*p*'s < .001, see Table 11 for pairwise correlations among the variables), we used multiple regression to test whether the other microlinguistic discourse measures of words per minute, grammatically correct utterances, and phonologically well-formed words had a significant independent relationship with the microlinguistic picture naming measure after controlling for the other three microlinguistic measures. For the multiple regression, we looked for outliers using the criterion of a studentized residual greater than 2.5 and a Cook's D value greater than 2.5 times the mean Cook's D. s129 and s109 had studentized residuals of – 3.13 and 2.68 and a Cook's D of 2.72 and 2.67 respectively. Identified as outliers, we removed s129 and s109 from the microlinguistic discourse measures analysis.

Table 11. Pair-wise correlation probabilities between other microlinguistic discourse measures of proportion grammatically complete utterance, proportion well-produced words, and words produced per minute at the acute time point.

Pairwise Correlations

Variable	by Variable	Correlation	Count	Lower 95%	Upper 95%	Signif Prob
Percentage of Grammatically Complete Utterances	Proportion of Well Produced Words	0.6777	16	0.2740	0.8783	0.0039*
Words Per Minute	Proportion of Well Produced Words	0.6876	16	0.2912	0.8825	0.0032*
Words Per Minute	Percentage of Grammatically Complete Utterances	0.6367	16	0.2060	0.8607	0.0080*

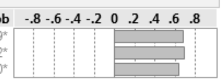


Table 11. Significant correlations are indicated by an '*'. No outliers removed.

See Table 12 (A-B) and Figure 2 (A-C) for results. As predicted, we found that the less accurate a picture was named, the fewer well-produced words produced. Naming accuracy did not predict the proportion of grammatically complete utterances nor words per minute produced (p's > .25).

Table 12. Results of multiple regression (p-values for significant beta coefficients indicated by '*').

A. Overall model.

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	0.06874552	0.022915	9.4872
Error	10	0.02415366	0.002415	Prob > F
C. Total	13	0.09289918		0.0028*

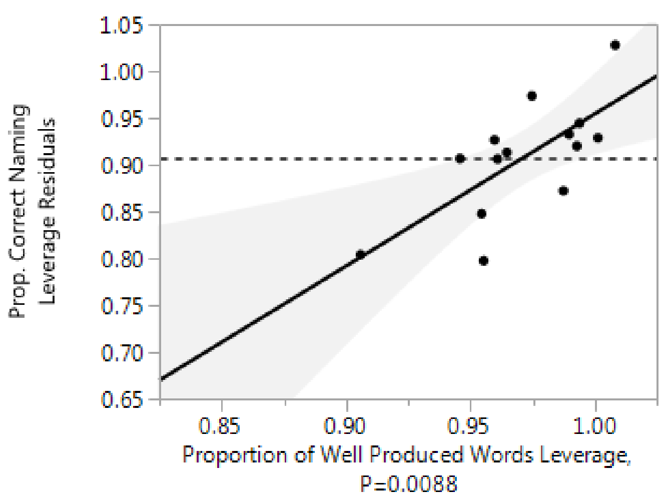
B. Other microlinguistic discourse measures.

Parameter Estimates

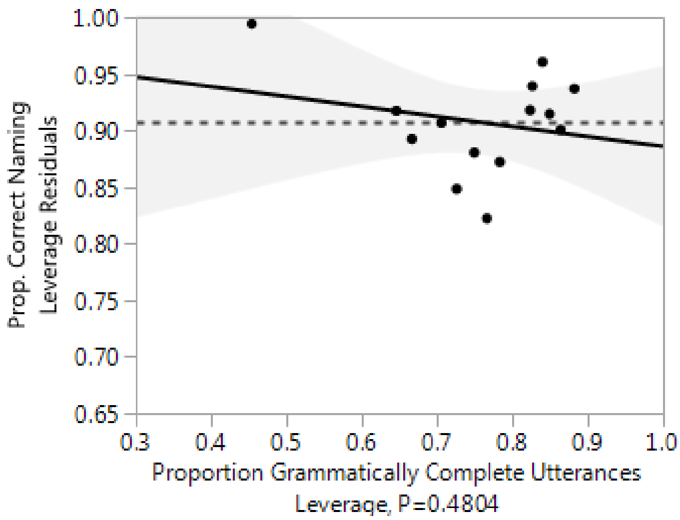
Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.667366	0.422335	-1.58	0.1451
Proportion of Well Produced Words	1.6252283	0.501369	3.24	0.0088*
Percentage of Grammatically Complete Utterances	-0.087735	0.119698	-0.73	0.4804
Words Per Minute	0.0006086	0.0005	1.22	0.2516

Figure 2 (A-C). Multiple regression scatterplots demonstrating the independent contributions of microlinguistic measures (proportion of well-produced words, proportion of grammatically complete utterances, and words per minute) to proportion accuracy in naming at the acute time point.

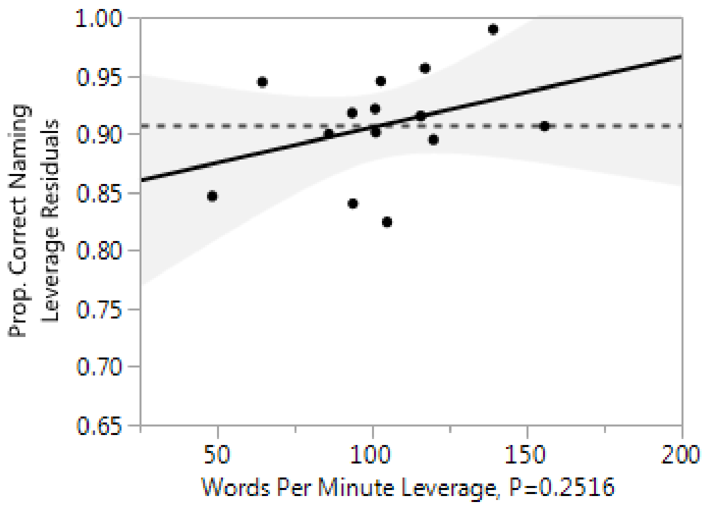
A. Proportion of well-produced words.



B. Proportion of grammatically complete utterances.



C. Words per minute.



Sub-Acute Sample: Recovery

Changes were observed from this acute sample's deficits to their deficits at the sub-acute time point (see Tables 13 and 14). Of the five subjects who demonstrated an issue with picture naming at the acute time point, two subjects improved on this measure and three stayed the same. Interestingly, one subject who was originally within the range of control data for picture naming did worse than controls at the sub-acute time point. In total, four out of sixteen subjects still had an issue with picture naming, exhibiting that overall some subjects that had deficits at the acute phase had persistent deficits at the sub-acute phase.

Table 13. Results for each subject for microlinguistic variables at the sub-acute time point, including min, max, and mean.

Microlinguistic Results: Sub-Acute Time Point				
Subject #	**Picture Naming**	**Well Produced Words**	**Grammatically Complete Utterances**	**Words Per Minute**
s18	0.936	0.978	0.655	123
s19	**0.681***	**0.766***	0.706	68
s20	0.936	0.990	0.712	119
s21	0.936	0.985	0.852	98
s25	0.936	1.000	0.813	144
s49	0.979	1.000	0.833	126
s55	0.957	0.971	1.000	129
s78	**0.766***	0.983	0.838	120
s92	**0.894***	**0.928***	**0.615***	103
s100	0.936	0.979	0.794	151
s104	0.936	1.000	0.863	169
s109	0.936	0.978	0.886	88
s115	0.979	1.000	0.909	149
s126	**0.872***	0.978	0.636	95
s128	0.957	1.000	0.767	142
s129	**0.0426***	**0.783***	**0.429***	**20***
MIN	**0.043**	**0.766**	**0.429**	**20.000**
MAX	**0.987**	**1.000**	**1.000**	**169.000**
MEAN	**0.869**	**0.957**	**0.769**	**115.250**

Table 13. An '*' indicates performance significantly below controls at the p < .05 level (one-tailed) following Crawford and Garthwaite (2007).

Of the five subjects who showed a deficit in phonologically well-formed words compared with controls at the acute time point, three of those subjects improved and two of them remained impaired at the one month-time point. Interestingly, one subject who was originally within the range of control data for phonologically well-formed words did worse than controls on this measure at the sub-acute time point. In total, only three out of sixteen subjects still had an issue with phonological word production demonstrating that overall some subjects that had deficits at the acute phase had persistent deficits at the subacute phase.

Of the five subjects who showed a deficit in speech rate (words per minute) at the acute time point compared with controls, it appears that four of them improved and one of them remained impaired at the sub-acute time point. In total, only one subject still had decreased production of words per minute demonstrating that overall only one subject that had deficits at the acute phase had persistent deficits at the subacute phase.

Of the three subjects who showed a deficit in grammatical processing compared with controls at the acute time point, it appears that two subjects improved and one of them remained impaired at the sub-acute time point. Interestingly, one subject who was originally within the range of control data for percentage of grammatically correct utterances did worse than controls on this measure at the sub-acute time point. In total, only two out of sixteen subjects still showed deficits in grammatical processing, demonstrating that overall some subjects that had deficits at the acute phase had persistent deficits at the subacute phase.

To summarize, of the eight subjects who showed difficulty with some type of microlinguistic aspects of discourse production (measured by either words per minute, proportion of correct pictures named, percentage of grammatically produced utterances, or proportion of phonologically well-formed words), four of those subjects improved and were no longer impaired on any microlinguistic measures at the sub-acute time point. However, the remaining four subjects continued to show impairments on at least one microlinguistic measure at the sub-acute time point. A total of four out of sixteen subjects still had issues with at least one microlinguistic measure at one month, demonstrating that overall, our cohort was split for recovery of microlinguistic aspects of discourse- half remained impaired on at least one microlinguistic aspect of discourse after one month but half had recovered to the range of normal (as compared with controls) and no longer showed impairments (see Figure 3 below).

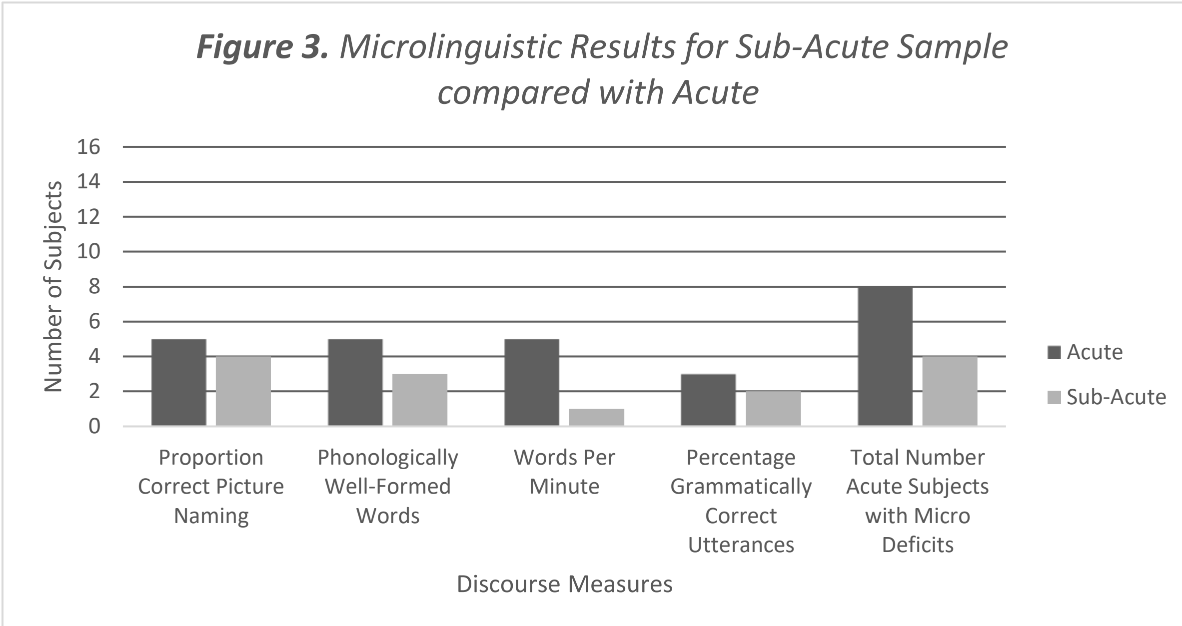


Figure 3. Details how many out of 16 total subjects at sub-acute point experienced microlinguistic deficits in discourse when compared with the data from the acute time point.

Changes over time were also observed for macrolinguistic aspects of discourse in our sample (see Table 14 below). Of the three subjects who showed a deficit in thematic selection compared with controls at the acute time point, it appears that all three subjects improved and were no longer impaired on this measure at the sub-acute time point. One possible explanation for this may be that subjects remembered the story better having told it in a similar setting 4-12 weeks prior.

Of the six subjects who showed a deficit in production of CIU's compared with controls at the acute time point, it appears that two subjects improved and were no longer impaired on this measure at the sub-acute time point and four subjects remained impaired and did not show recovery. Interestingly, two subjects who were originally within the range of control data for percentage of grammatically correct utterances did worse than controls on this measure at the sub-acute time point. A total of six out of sixteen subjects still had issues at one month with proportion of CIUs produced, exhibiting the persistence of this macrolinguistic informativeness deficit. Four out of sixteen subjects still had a deficit with macrolinguistic informativeness of only the proportion of CIUs, and two new subjects also showed deficits with the proportion of CIU's, yielding six total subjects that had difficulty with informativeness at the sub-acute time point.

Table 14. Results for each subject at the sub-acute time points for macrolinguistic variables, including min, max, and mean.

Macrolinguistic Results: Sub-Acute Time Point					
Subject #	**Cohesive Error Score**	**Local Coherence Error Score**	**Global Coherence Error Score**	**% CIUs**	**Thematic Selection**
s18	0.064	0.055	**0.218***	**0.779***	0.588
s19	**0.091***	**0.176***	**0.235***	**0.762***	0.206
s20	**0.089***	0.017	**0.220***	**0.729***	0.765
s21	0.000	0.000	0.037	0.840	0.618
s25	0.053	0.063	0.125	0.874	0.500
s49	0.000	0.000	0.000	0.972	0.294
s55	0.000	0.000	0.000	0.910	0.324
s78	0.000	0.108	0.108	0.911	0.559
s92	0.000	0.000	0.077	0.845	0.265
s100	0.000	0.000	0.029	0.919	0.676
s104	0.020	0.078	0.039	0.943	0.647
s109	0.023	0.029	0.086	**0.789***	0.588
s115	0.017	0.000	0.136	**0.778***	0.500
s126	0.000	0.000	0.091	0.933	0.206
s128	0.000	0.000	0.000	0.997	0.588
s129	**0.714***	**0.429***	**0.571***	**0.167***	0.000
MIN	**0.000**	**0.000**	**0.000**	**0.167**	**0.000**
MAX	**0.622**	**0.714**	**0.571**	**0.997**	**0.765**
MEAN	**0.135**	**0.067**	**0.123**	**0.822**	**0.458**

Table 14. An "*' indicates performance significantly below controls at the p < .05 level (one-tailed) as determined by Crawford and Garthwaite (2007).

For other macrolinguistic measures of discourse, of the six subjects who showed a deficit in cohesive ties compared with controls at the acute time point, three subjects improved and were no longer impaired on this measure at the sub-acute time point and three subjects remained impaired and did not show improvement. A total of three out of sixteen subjects still had deficits at one month with cohesive ties, exhibiting that overall our cohort was split- half remained impaired when producing cohesive ties after one month, but half improved.

Of the four subjects who had issues with local coherence compared with controls at the acute time point, two of those subjects improved and were no longer impaired on this measure at the sub-acute time point and the other two subjects remained impaired and did not show recovery. A total of two out of sixteen subjects still had a deficit in local coherence at one month, exhibiting that overall our cohort was again split- half remained impaired on local coherence after one month, but half had improved.

Of the seven subjects who had issues with global coherence compared with controls at the acute time point, three of those subjects improved and were no longer impaired on this measure at the sub-acute time point. However, the other four subjects remained impaired at the sub-acute time point. A total of four out of sixteen subjects still had issues with global coherence at one month.

In summary, of the eleven subjects that had issues with some type of macrolinguistic measure compared with controls at the acute time point, it appears that five of those subjects improved and were no longer impaired on any macrolinguistic measures at the sub-acute time point (refer to Table 14). However, four subjects remained impaired on at least one macrolinguistic measure at the sub-acute time point. Interestingly, two subjects who were originally within the range of control data for all macrolinguistic measures did worse than controls on at least one of these macrolinguistic measures at the sub-acute time point. A total of seven out of sixteen subjects had issues with at least one macrolinguistic measure at the sub-acute time point (see Figure 4 below).

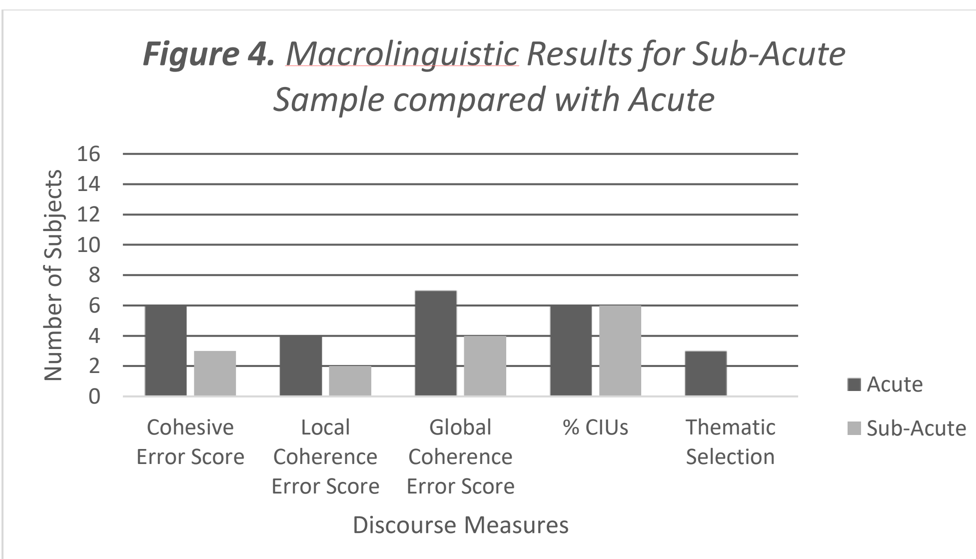


Figure 4. Details how many out of 16 total subjects at sub-acute point experienced macrolinguistic deficits in discourse when compared with the data from the acute time point.

Sub-Acute Stroke Analysis

Next, we again compared the microlinguistic measure picture naming with each macrolinguistic variable (cohesion, coherence both local and global, CIU's, and thematic selection), this time for the sub-acute time point, to investigate if the correlations seen at the acute time point continue to hold true for this population after approximately one month of recovery. Because we found a trend towards significance between different discourse measures (*p*'s < .07, see Table 15 for pairwise correlations among the variables), we used multiple regression to test whether macrolinguistic discourse measures had a significant independent relationship with the microlinguistic naming measure after taking the other macrolinguistic measures into account. For the multiple regression, there were no outliers using the criterion of a studentized residual greater than 2.5 and a Cook's D value greater than 2.5 times the mean Cook's D.

Table 15. Pair-wise correlation probabilities between discourse measures.

Pairwise Correlations

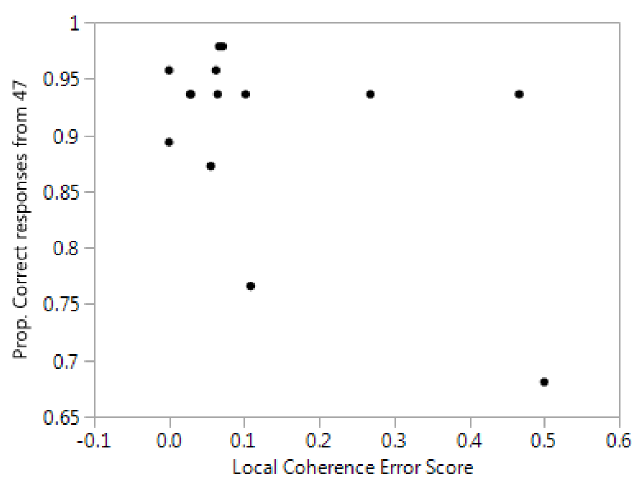
Variable	by Variable	Correlation	Count	Lower 95%	Upper 95%	Signif Prob
Cohesive Error Score	Percentage of Thematic Selection	-0.5380	15	-0.8233	-0.0355	0.0386*
Local Coherence Error Score	Percentage of Thematic Selection	-0.5510	15	-0.8292	-0.0540	0.0333*
Local Coherence Error Score	Cohesive Error Score	0.9230	15	0.7790	0.9745	<.0001*
Global Coherence Error Score	Percentage of Thematic Selection	-0.4592	15	-0.7865	0.0694	0.0851
Global Coherence Error Score	Cohesive Error Score	0.9160	15	0.7606	0.9721	<.0001*
Global Coherence Error Score	Local Coherence Error Score	0.8964	15	0.7103	0.9654	<.0001*
Proportion of CIUs	Percentage of Thematic Selection	0.4704	15	-0.0551	0.7919	0.0768
Proportion of CIUs	Cohesive Error Score	-0.9575	15	-0.9861	-0.8738	<.0001*
Proportion of CIUs	Local Coherence Error Score	-0.8765	15	-0.9584	-0.6610	<.0001*
Proportion of CIUs	Global Coherence Error Score	-0.9485	15	-0.9831	-0.8485	<.0001*
prop correct naming of 47	Percentage of Thematic Selection	0.6418	15	0.1931	0.8685	0.0099*
prop correct naming of 47	Cohesive Error Score	-0.9459	15	-0.9822	-0.8414	<.0001*
prop correct naming of 47	Local Coherence Error Score	-0.9631	15	-0.9879	-0.8899	<.0001*
prop correct naming of 47	Global Coherence Error Score	-0.8881	15	-0.9625	-0.6895	<.0001*
prop correct naming of 47	Proportion of CIUs	0.9026	15	0.7260	0.9675	<.0001*

Table 15. Significant p-values for correlations indicated by an *. No outliers removed.

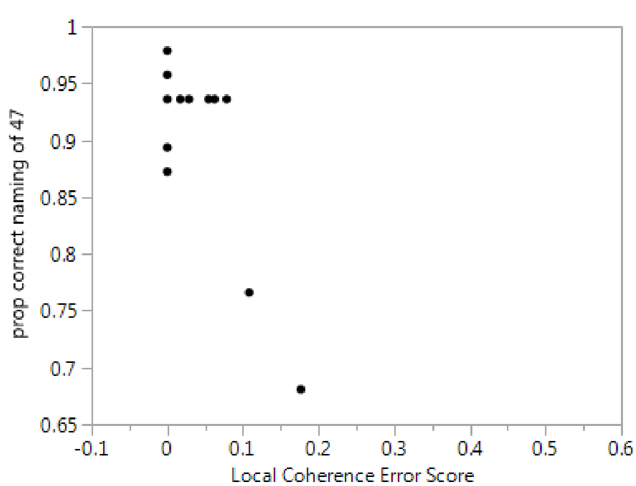
See Figure 6 (A-E) and Table 16 for results. In contrast to the acute analysis, we found no detectable relationship between proportion cohesive errors produced and proportion correct naming. However, there was still a correlation between naming and local coherence errors, but the direction of the correlation switched from a positive direction in the acute sample to a negative direction at the sub-acute time point. We now found at the sub-acute recovery time point, if a subject struggled to name pictures accurately, then they were likely to also make more local coherence errors ($p < .01$). However, although we found a significant relationship between local coherence errors and naming both acutely (in a positive direction) and at 1 month (in a negative direction), this appears to be driven by outliers in both cases. Figure 5 (A-B) displays the simple correlations between proportion correct naming and local coherence errors produced acutely and at one month. At one month (Figure 5B), two subjects who had poorer naming had an increase in local coherence errors but otherwise there was no relationship between performance for the remaining subjects. As seen in Figure 5A, acutely, subjects produced a range of coherence errors (prop. coherence error 0 - .5) independent of their ability to name (all at around 95% naming accuracy). Thus, we conclude that the significant relationships between coherence errors and naming both acutely and one month are spurious.

Figure 5. Simple correlations between proportion correct naming & proportion local coherence errors produced.

A. Acute data: local coherence error score.



B. Sub-acute data: local coherence error score.



Again, in contrast to the acute analysis, there was also a trend between naming accuracy and proportion themes produced that did not reach significance (p = .07). Consistent with the acute analysis, no other discourse factors predicted naming performance (p's > .32).

Table 16. Results of multiple regression (p-values for significant beta coefficients indicated by '*').

A. Overall model.

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	5	0.76986106	0.153972	55.0235
Error	10	0.02798299	0.002798	Prob > F
C. Total	15	0.79784405		<.0001*

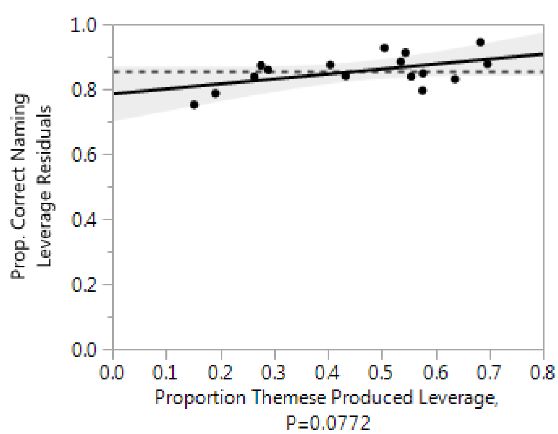
B. Discourse measures.

Parameter Estimates

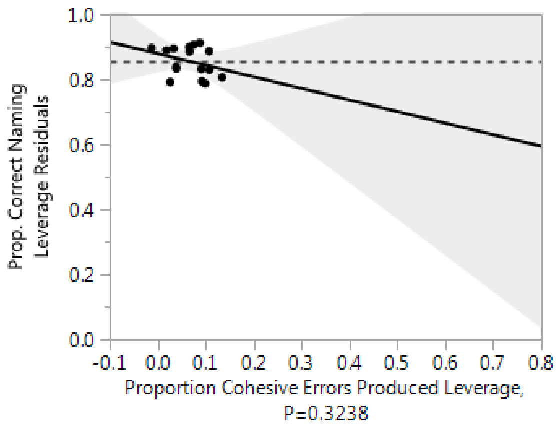
Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.7312144	0.307973	2.37	0.0390*
Percentage of Thematic Selection	0.1535959	0.077985	1.97	0.0772
Cohesive Error Score	-0.356527	0.343542	-1.04	0.3238
Local Coherence Error Score	-1.282673	0.369558	-3.47	0.0060*
Global Coherence Error Score	0.1751153	0.344515	0.51	0.6223
Proportion of CIUs	0.1609604	0.322582	0.50	0.6286

Figure 6 (A-E). Multiple regression scatterplots demonstrating the independent contributions of macrolinguistic measures to proportion correct naming at the sub-acute time point.

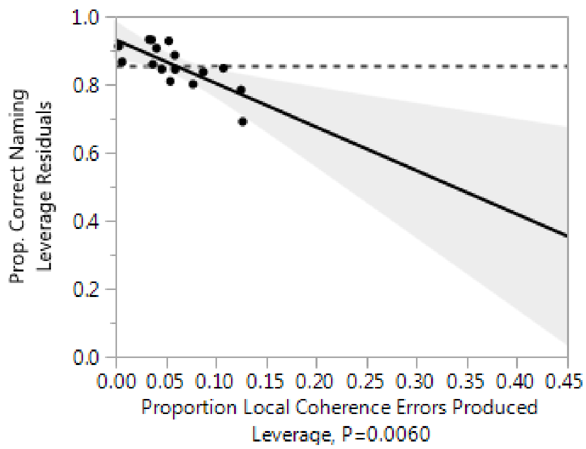
A. Proportion of thematic selection errors.



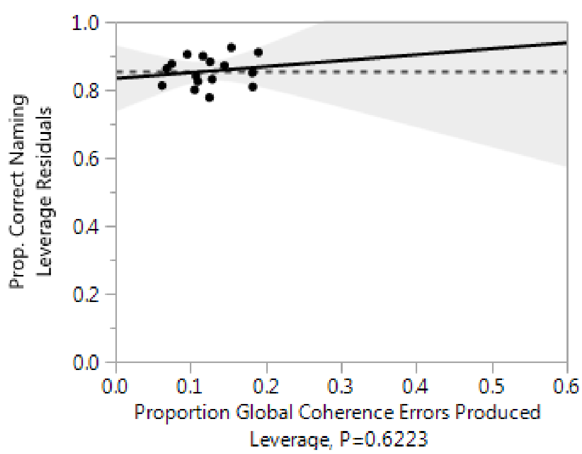
B. Proportion of cohesive errors.



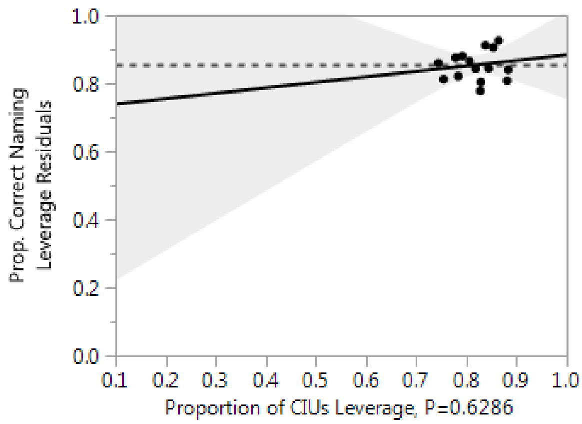
C. Proportion of local coherence errors.



D. Proportion of global coherence errors.



E. Proportion of CIUs produced.



Lastly, we again compared microlinguistic picture naming results with the remaining microlinguistic variables (words per minute, grammatically correct utterances, and phonologically well-formed words) for our cohort at the sub-acute time point**.** Because we found significant correlations between the different microlinguistic discourse measures (*p*'s < .01, see Table 17 for pairwise correlations among the variables), we used multiple regression to test whether the microlinguistic discourse measures of words per minute, grammatically correct utterances, and phonologically well-formed words had a significant independent relationship with the microlinguistic naming measure after controlling for the three other microlinguistic measures. For the multiple regression, we looked for outliers using the criterion of a studentized residual greater than 2.5 and a Cook's D value greater than 2.5 times the mean Cook's D. s129 and s19 had studentized residuals of – 3.16 and and 2.62 and a Cook's D of 3.5 and 4.00 respectively. Identified as outliers, we removed s129 and s19 from the remaining microlinguistic discourse measures analysis.

Table 17. Pair-wise correlation probabilities between remaining microlinguistic discourse measures of phonologically well-formed words, words per minute, and grammatically complete utterances.

Pairwise Correlations

Variable	by Variable	Correlation	Count	Lower 95%	Upper 95%	Signif Prob	-.8 -.6 -.4 -.2 0 .2 .4 .6 .8
Percentage of Grammatically Complete Utterances	Proportion of Well Produced Words	0.6085	16	0.1616	0.8483	0.0124*	
Words Per Minute	Proportion of Well Produced Words	0.8015	16	0.5073	0.9283	0.0002*	
Words Per Minute	Percentage of Grammatically Complete Utterances	0.6569	16	0.2390	0.8695	0.0057*	

Table 17. Significant correlations (p < .05) indicated by ''. No outliers removed.*

See Table 18 and Figure 7 for the results. We found no significant results. In contrast to the acute sample, no other microlinguistic variable (Words per Minute, grammatically correct utterances, nor phonologically well-formed words) correlated with picture naming. This is surprising because we expected picture naming to remain correlated with phonologically well-formed words as these subjects recovered. We feel that the most likely explanation for this is that the performance of the subjects at the sub-acute time point on picture naming and phonologically well-formed words had reached near ceiling, and this lead to a lack of variability within the samples.

Table 18. Results of multiple regression (p-values for significant beta coefficients indicated by '*').

A. Overall model.

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	0.00565130	0.001884	0.5860
Error	10	0.03214861	0.003215	Prob > F
C. Total	13	0.03779991		0.6378

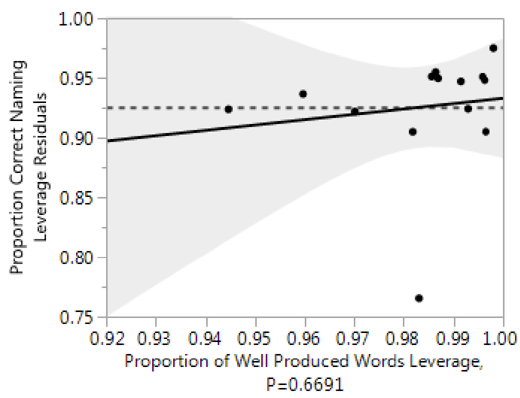
B. Other microlinguistic discourse measures at the sub-acute time point.

Parameter Estimates

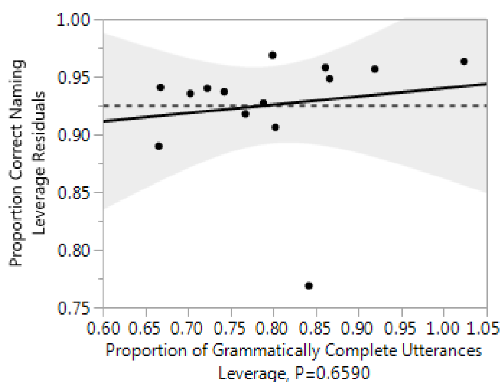
Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.3763873	0.921501	0.41	0.6916
Proportion of Well Produced Words	0.4462063	1.013527	0.44	0.6691
Percentage of Grammatically Complete Utterances	0.0717292	0.157732	0.45	0.6590
Words Per Minute	0.000423	0.000777	0.54	0.5980

Figure 7. Multiple regression scatterplots demonstrating the independent contributions of microlinguistic measures to proportion correct naming.

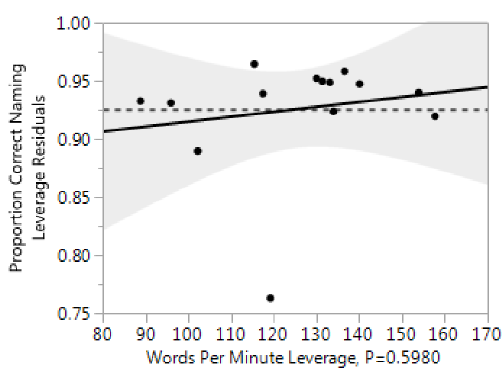
A. Proportion of well-produced words.



B. Proportion of grammatically complete utterances.



C. Words per minute.



VII. General Discussion

The primary goal of this project was to describe the incidence of discourse deficits for a left hemisphere acute stroke population compared with a control population. In total, 69% of our population had some type of discourse deficit acutely, either microlinguistic or macrolinguistic compared with the controls. For our population at the acute stage, 69% of subjects showed deficits on macrolinguistic aspects of discourse, whereas only 50% of subjects showed deficits on microlinguistic aspects of discourse, indicating that macrolinguistic deficits were most prevalent for our cohort. These data contrast with information in the literature which reported that left hemisphere stroke primarily exhibits more deficits in microlinguistic skills, and right hemisphere stroke primarily exhibits more deficits in macrolinguistic skills (Karaduman, Gökson, & Chatterjee, 2017). Of the 11 total subjects that showed discourse deficits, 55% had both micro and macro deficits, 27% had only macrolinguistic deficits, and 18% had only microlinguistic deficits. Therefore, for our population, subjects who had discourse deficits most often had a combination of both microlinguistic and macrolinguistic issues. However, there was a subset that demonstrated macrolinguistic deficits without the presence of microlinguistic deficits, confirming the possibility for macrolinguistic deficits to be unrelated to microlinguistic language processing for this population. This information supports the idea that stroke survivors can demonstrate deficits in discourse that would not be identified using traditional aphasia assessments, which focus mostly on microlinguistic deficits (Barker et al., 2017). The reverse was also true for a smaller percentage of our cohort- we saw subjects who had microlinguistic deficits with no detectable problems with macrolinguistic structure. This is in line with studies in the aphasia literature which found that patients who struggle with micro aspects of discourse can still have intact macrostructure, allowing them to communicate a message or idea (Linnik et al., 2016). Because our subjects are a cohort of acutely diagnosed left-hemisphere stroke, *a priori* it was unclear what the incidence of their discourse deficits would be, if any, and whether a subset of these subjects would follow patterns established in literature for chronic aphasia. We can now confirm that over half our left hemisphere acute stroke subjects experienced discourse deficits, and of this group, there were subsets of individuals that followed different profiles of deficits established in aphasia literature.

Considering the most frequent macrolinguistic deficits for the acute time point, most subjects who had deficits on macrolinguistic deficits had either a deficit in cohesion, global coherence, or proportion of CIU’s. It is important to consider which types of errors for these variables were most frequent and prevalent for acute subjects, because this may help clinicians in practice identify subjects who use these error types frequently as having disordered macrolinguistic discourse. For cohesion, error types of aposiopesis and personal errors were most prevalent (see Table 19). For global coherence, tangential and filler utterances were the most prevalent error types (see Table 20). In clinical practice, these error types would be most beneficial for clinicians to be aware of when considering patients who may have discourse deficits.

Table 19. Most common cohesive error types.

Cohesive Errors by Type for Acute Subjects					
Subject Number	**Personal Errors**	**Demonstrative Errors**	**Additive Errors**	**Aposiopesis Errors**	**Total Errors**
S18	4	0	0	3	7
S19	11	1	1	8	21
S20	1	1	1	5	8
S25	13	1	1	1	16
S78	5	0	0	5	10
S129	10	0	0	13	23

Table 20. Most common global coherence error types.

Global Coherence Errors by Type for Acute Subjects					
Subject Number	**Filler Utterances**	**Propositional Repetitions**	**Tangential Utterances**	**Conceptually Incongruent Information**	**Total Errors**
S18	11	3	1	0	15
S19	2	1	2	2	7
S20	3	1	11	0	15
S49	0	1	2	0	3
S78	4	2	6	0	12
S126	0	1	2	0	3
S129	0	0	5	4	9

There were several patterns of recovery observed for the group of participants who exhibited a deficit on one or more aspects of discourse. Of the total group of subjects who demonstrated one or more deficits acutely, 27% of them continued to have persisting deficits in the same aspects at the subacute time point. One explanation for this may be that this group was overall more severe, and therefore showed less overall recovery at the second time point. Another 27% recovered in macro aspects of discourse but did not show recovery in micro aspects. In contrast, a smaller group (9% of subjects who had discourse deficits acutely) recovered in micro aspects but not macro aspects at the sub-acute time point. This possibly indicates that for our cohort, macro aspects were more likely to recover at the sub-acute time point than micro deficits. 18% experienced only macrolinguistic deficits acutely but had recovered at the sub-acute time point. Another 18% of participants with acute deficits showed problems with micro deficits at the acute time point, but as they recovered, interestingly now showed macro deficits at the sub-acute time point. In conclusion, subjects who had discourse deficits acutely tended to either have persistent deficits (possibly due to overall severity) or had recovered in macro aspects of discourse but not micro at the sub-acute time point.

A secondary goal of this project was to determine whether macro aspects of discourse were related to micro aspects of discourse, as seen in chronic aphasia populations (Andreetta & Marini 2015; Wright & Capilouto 2012). We investigated our prediction that the microlinguistic picture naming measure reflecting lexical retrieval would correlate to macrolinguistic measures of cohesion, local coherence, global coherence, thematic selection, and content information units (CIUs) for our population, based on previous work by Marini, Andreetta, and colleagues (2015, 2014, 2012). A correlation between the microlinguistic measure of picture naming and cohesive error score for the acute population indicates a relationship between lexical retrieval and cohesion for our acute subjects, which is similar to a description by Andreetta and Marini (2015), about their cohort of subjects with anomic aphasia. This relationship which was consistent with one of our predictions suggesting that a speaker who has a lexical retrieval deficit may also demonstrate an overdependence on non-specified nouns or noun substitutes (aka, incorrect or ambiguous referents), contributing to a higher error score in cohesion. This seems to hold true for subjects who had deficits in cohesion, as errors of the personal cohesion type were the highest frequency of type of cohesion errors. The second highest frequency of error type for subjects who had significant cohesion deficits was aposiopesis, indicating that the speaker's thought was discontinued mid-sentence (possibly due to word finding deficits) but after the interruption, the speaker was able to recover and finish their thought. It should be noted that, also likely driving this correlation, as a group our cohort made more cohesion errors than any other type of error throughout the analysis. Since cohesive ties are considered at the word level, but coherence is considered at the level of the entire utterance, there was much more opportunity for such errors to occur in the cohesion analysis.

Contrary to our predictions, microlinguistic naming at the acute stage of stroke did not correlate with any other macrolinguistic measures other than cohesion. However, acute subjects did still show deficits on macrolinguistic variables. 64% of all acute subjects had deficits on global coherence, 38% had deficits in CIU production, 25% had deficits on local coherence, and 19% had deficits in thematic selection. Of the 5 acute subjects who had deficits in naming, two of them seemed to be more severely impacted by their strokes because they showed deficits in almost every level of analysis. However, for the other three subjects, their performance on macrolinguistic aspects of discourse varied. These subjects were not easily comparable to each other and it was difficult to discern a pattern in their deficit profiles. It is clear though that some of these subjects who had deficits in picture naming also had a mix of deficits in local coherence, global coherence, thematic selection, and proportion of CIU's. These different profiles for deficits across this group of subjects likely canceled out any detectable correlations between subjects that were similar. A relationship, however, was observable considering the 7 subjects from the acute population who showed deficits in global coherence. Almost all of them (6) also had deficits in CIU count because utterances coded as global coherence errors cannot be included in CIU proportion. If a subject had frequent global coherence errors (i.e. errors linking one sentence to a previous sentence), this also drove their CIU proportion lower. Lastly, there is one more interesting observation to note regarding the subjects who had deficits in CIU proportion (of which there were 6, or 38% of the sample). Most of these subjects (4 out of 6) also had a deficit in naming. However, a subset of subjects (2) who had a deficit in CIU proportion but did not have a deficit in microlinguistic picture naming. For these two subjects, their CIU proportion was likely driven lower by their production of global coherence errors, as mentioned above. Conversely, there was one subject who had a microlinguistic naming deficit but actually produced a proportion of CIUs *that was statistically higher than* controls. These data suggest that although this subject may have struggled to name during an externally evoked picture confrontation naming task which required the retrieval of the specific target, they were still able to produce accurate content words to communicate their ideas during an internally evoked narrative, where there are more degrees of freedom to produce related lexical items. This contributes further support to the previously reported claim that patients who struggle with micro aspects of discourse may still have intact macrostructure, allowing them to communicate a message or idea (Linnik et al., 2016).

We also investigated whether the microlinguistic picture naming measure reflecting lexical retrieval correlated with the remaining microlinguistic measures of grammatical processing and phonologically well-formed words, per our predictions. There was no detectable correlation between picture naming and our grammatical measure for the acute sample, indicating that the ability to retrieve the name of a line drawing was unrelated to morphological retrieval for our population. We had suspected that an impairment in lexical retrieval would correlate with an impairment in morphological retrieval because current models of discourse maintain that speakers gain access to morphosyntactic and morphological features through lexical access (Marini et al., 2011). This correlation has been observed in the literature on microlinguistic measures in aphasia populations. Conversely, there was a correlation between picture naming and phonologically well-formed words. This correlation appeared, as expected, but this was probably related to overlapping constructs of our dependent variables for lexical retrieval and phonological production. Phonological production was also included as part of our measure of picture naming, because for each subject to get credit for the picture they named, they had to use the phonologically correct form of the word. As an initial pass to get an idea of naming accuracy for this cohort, we used a naming accuracy measure that was different than how Andreeta, Marini, and colleagues calculated naming, which was by error typing. A future direction could be to classify error types when measuring naming accuracy, which might offer a more complete description about the relationship between lexical retrieval and phonological production for left hemisphere acute stroke populations.

At the sub-acute time point, we again examined these data to determine whether correlations held between the microlinguistic measure of picture naming and each macrolinguistic variable- cohesion, local and global coherence, CIUs, and thematic selection. At this time point, there was no longer a detectable correlation between cohesion and microlinguistic picture naming. This may in part stem from the degree of improvement subjects experienced for this measure. No subject made more than 10% cohesive errors at the sub-acute time point (range 0 – .1), in comparison to at the acute stage (range 0 – .5), with the exception of one outlier subject.

VIII. Conclusions

Approximately 38% of people admitted to hospitals for acute stroke demonstrate symptoms of aphasia at the time of admission (Pedersen, Jørgensen, Nakayama, Raaschou, & Olsen, 1995). Since our cohort reflected an amount close to these data with 50% of our subjects demonstrating microlinguistic deficits at the acute time point, our subjects seem to be a similar representation of the deficits of acute stroke survivors. Most notably, this project demonstrated that aphasia batteries used in medical settings may not detect subtle macrolinguistic discourse deficits that are exhibited by stroke survivors.

This project supports the need for multilevel assessment, examining both structural and functional linguistic processing, when examining discourse for patterns of recovery (Marini et al., 2011). Because our sample of subjects was inclusive of different severities and deficits, multilevel assessment was useful in creating a picture of the severities and types of deficits for each individual subject. This method of multilevel assessment is indeed time consuming and not usually feasible for practicing clinicians to apply with every patient. However, our data demonstrated that close attention to cohesion errors of the personal and aposiopesis type, global coherence errors including filler and tangential utterances, and a calculation of proportion of CIUs spoken by patients may be a quicker and more efficient way to consider whether patients who do not have outright aphasia symptoms still have deficits in discourse production following stroke.

Limitations and Future Directions

Because our subjects performed near ceiling on some measures at the subacute time point, a future direction could be to incorporate a reaction time measure instead of accuracy. This method could detect subtle deficits in measures such as picture naming when accuracy is high among subjects. Another potential future direction could be to recruit a larger group of controls that are acutely hospitalized, but without neurological diagnoses to account for more variability within the sample. It was an interesting finding that macrolinguistic deficits showed more recovery at the one-month time point than microlinguistic deficits. Future studies should investigate why macrolinguistic deficits seem to recover faster than microlinguistic deficits from an acute to one-month time point. It would be useful to explore whether any variables could predict this recovery at the macrolinguistic level, to make it possible to identify which subjects might have a persistent deficit. It was beyond the scope of this study to examine correlations between macrolinguistic deficits, but this should be considered as a future direction for the literature on this subject. For the lexical retrieval measure in this study, we used a confrontation naming task and as an initial pass, only considered accuracy. Previous work on this subject considered error types when measuring lexical retrieval (Andreeta, Marini and colleagues, 2011, 2012, 2014, & 2015). Future studies using confrontation naming as a measure of lexical retrieval could consider error types to make this measure more comparable to previous work. Finally, more research is needed to determine if the discourse measures that were more prevalent in the acute phase can be used in a larger population to reliably identify discourse deficits and aphasia post stroke, using a more complete aphasia assessment to compare with discourse performance.

Appendix A. Picture naming stimuli.

Picture Name	*Letter Length*	*# Syllables*	*HAL Lexical Frequency*
almonds	7	2	452
axe	3	1	3,070
belt	4	1	10820
book	4	1	190905
boot	4	1	43868
broom	5	1	600
cabbage	7	2	1,124
cat	3	1	38649
chain	5	1	23315
cheese	6	1	8662
clock	5	1	24496
coat	4	1	10295
coins	5	1	4460
crayon	6	2	307
doll	4	1	5685
duck	4	1	6829
feather	7	2	2,364
fork	4	1	11253
fox	3	1	13959
hammer	6	2	6,714
harp	4	1	1,667
house	5	1	104153
key	3	1	95993
leaf	4	1	7051
mitten	6	2	139
mop	3	1	723

mushroom	8	2	1,873
nose	4	1	13919
pear	4	1	971
pickle	6	2	979
pig	3	1	6,375
pill	4	1	2,805
rabbit	6	2	5751
ribbon	6	2	3592
rock	4	1	44285
rope	4	1	6,358
ruler	5	2	2,703
scarf	5	1	826
seal	4	1	6,421
ship	4	1	51299
staples	7	2	1,124
sweater	7	2	1314
toast	5	1	3,064
toothbrush	10	2	560
van	3	1	45556
vase	4	1	540
Average	4.9	1.3	17780
Min	3.0	1.0	139
Max	10.0	2.0	190905

Appendix B. Control data.

Microlinguistic Variables				
Control Subjects	**Picture Naming**	**Well Produced Words**	**Grammatically Complete Utterances**	**Words Per Minute**
AK	0.936	0.991	0.908	199
CT	0.957	1.000	0.800	114
CW	0.979	1.000	0.707	167
DM	0.979	1.000	0.805	133
DR	0.979	0.997	0.927	156
EW	1.000	0.971	0.842	86
GD	1.000	0.969	0.667	97
GH	1.000	1.000	0.716	163
JK	0.915	0.994	0.773	142
KV	1.000	1.000	0.794	130
LG	0.957	0.994	0.833	91
LS	0.979	0.996	0.971	129
RW	1.000	1.000	1.000	169
TM	0.915	0.972	0.725	133
MIN	**0.870**	**0.969**	**0.667**	**86.000**
MAX	**0.987**	**1.000**	**1.000**	**199.000**
MEAN	**0.935**	**0.992**	**0.819**	**136.357**
ST DEV	**0.031**	**0.012**	**0.102**	**32.599**

Macrolinguistic Variables					
Control Subjects	**Cohesive Error Score**	**Local Coherence Error Score**	**Global Coherence Error Score**	**Proportion of CIUs**	**Percentage of Thematic Selection**
AK	0.010	0.031	0.046	0.811	0.794
CT	0.056	0.100	0.000	0.971	0.176
CW	0.048	0.122	0.122	0.808	0.618
DM	0.020	0.080	0.069	0.905	0.765
DR	0.000	0.024	0.049	0.938	0.706
EW	0.077	0.053	0.000	0.798	0.294
GD	0.071	0.133	0.000	0.894	0.353
GH	0.033	0.037	0.086	0.882	0.676
JK	0.009	0.061	0.121	0.873	0.765
KV	0.014	0.000	0.118	0.898	0.500
LG	0.016	0.033	0.067	0.942	0.559
LS	0.000	0.000	0.071	0.870	0.412
RW	0.000	0.000	0.000	0.894	0.294
TM	0.086	0.118	0.078	0.915	0.529
MIN	**0.000**	**0.000**	**0.000**	**0.798**	**0.176**
MAX	**0.086**	**0.133**	**0.122**	**0.971**	**0.794**
MEAN	**0.031**	**0.169**	**0.059**	**0.886**	**0.532**
ST DEV	**0.031**	**0.047**	**0.044**	**0.050**	**0.201**

References

Andreetta, S. (2014). Features of narrative language in fluent aphasia (Doctoral thesis). Università degli Studi di Udine, Italy.

Andreetta, S., Cantagallo, A., & Marini, A. (2012). Narrative discourse in anomic aphasia. *Neuropsychologia, 50*, 1787–1793. doi:10.1016/j.neuropsychologia.2012.04.003

Andreetta, S., & Marini, A. (2015). The effect of lexical deficits on narrative disturbances in fluent aphasia. *Aphasiology*, *29*, 705–723. doi:10.1080/02687038.2014.979394

Barker, M. S., Young, B., & Robinson, G. A. (2017). Cohesive and coherent connected speech deficits in mild stroke. *Brain & Language, 168*, 23-36. http://dx.doi.org/10.1016/j.bandl.2017.01.004

Brookshire, R. H., & Nicholas, L. E. (1994). Speech sample size and test-retest stability of connected speech measures for adults with aphasia. *Journal of Speech, Language, and Hearing Research, 37*, 399–407. doi:10.1044/jshr.3702.399

Cloutman, L. L., Newhart, M., Davis, C. L., Kannan, V. C., & Hillis, A. E. (2010). Patterns of reading performance in acute stroke: A descriptive analysis. *Behavioural neurology*, *22*(1-2), 35-44.

Coelho, C. A. & Flewellyn, L. (2003). Longitudinal assessment of coherence in an adult with fluent aphasia: a follow-up study. *Aphasiology, 17,* 173-182.

Crawford, J. R., & Garthwaite, P. H. (2007). Comparison of a single case to a control or normative sample in neuropsychology: Development of a Bayesian approach. *Cognitive Neuropsychology*, *24*(4), 343-372.

Crawford, J. R., Garthwaite, P. H., & Ryan, K. (2011). Comparing a single case to a control sample: testing for neuropsychological deficits and dissociations in the presence of covariates. *cortex*, *47*(10), 1166-1178.

Ellis, C., Henderson, A., Wright, H. H., & Rogalski, Y. (2016). Global coherence during discourse production in adults: a review of the literature. *International Journal of Language & Communication Disorders, 51*(4), 359-367. doi:10.1111/1460-6984.12213

Ellis, C., Rosenbek, J. C., Rittman, M. R., & Boylstein, C. A. (2005). Recovery of cohesion in narrative discourse after left-hemisphere stroke. *The Journal of Rehabilitation Research and Development, 42*(6), 737. doi:10.1682/jrrd.2005.02.0026

Halliday, M. A. K., & Hasan, R. (1976). *Cohesion in English*. London, UK: Longman.

Helm-Estabrooks, N. A., & Ramsberger, G. (1986). Treatment of agrammatism in long-term Broca's aphasia. *British Journal of Disorders of Communication*, *21*(1), 39–45.

Hillis, A. E., & Heidler, J. (2002). Mechanisms of early aphasia recovery. *Aphasiology*, *16*(9), 885-895.

Hillis, A. E., Kleinman, J. T., Newhart, M., Heidler-Gary, J., Gottesman, R., Barker, P. B., ... & Chaudhry, P. (2006). Restoring cerebral blood flow reveals neural regions critical for naming. *Journal of Neuroscience*, *26*(31), 8069-8073.

Karaduman, A., Göksun, T., & Chatterjee, A. (2017). Narratives of focal brain injured individuals: A macro-level analysis. *Neuropsychologia*, *99*, 314-325.

Kong, A. P. (2016). *Analysis of neurogenic disordered discourse production: from theory to practice*. New York, NY: Routledge.

Linnik, A., Bastiaanse, R., & Hohle, B. (2016). Discourse Production in aphasia: a current review of theoretical and methodological challenges. *Aphasiology, 30*(7), 765-800. http://dx.doi.org/10.1080/02687038.2015.1113489

Marini, A., Andreetta, S., Del Tin, S., & Carlomagno, S. (2011). A multi-level approach to the analysis of narrative language in aphasia. *Aphasiology, 25*, 1372–1392. doi:10.1080/ 02687038.2011.584690

Marini, A., Caltagirone, C., Pasqualetti, P., & Carlomagno, S. (2007). Patterns of language improvement in adults with non-chronic non-fluent aphasia after specific therapies. *Aphasiology*, *21*(2), 164–186.

McNeil, M. R., Doyle, P. J., Fossett, T. R. D., Park, G. H., & Goda, A. J. (2001). Reliability and concurrent validity of the information unit scoring metric for the story retelling procedure. *Aphasiology, 15,* 991–1006. doi:10.1080/02687040143000348

Miller, J. F., Andriacchi, K., & Nockerts, A. (2011). *Assessing language production using SALT software: A clinician's guide to language sample analysis*. Middleton, WI: SALT Software, LLC.

Nicholas, L. E., & Brookshire, R. H. (1993). A system for quantifying the informativeness and efficiency of the connected speech of adults with aphasia. *Journal of Speech Language and Hearing Research, 36*, 338–350. doi:10.1044/jshr.3602.338

O'Sullivan, M., Lepage, M., Bouras, M., Montreuil, T., & Brodeur, M. B. (2012). North-American norms for name disagreement: Pictorial stimuli naming discrepancies. *PloS one*, *7*(10), e47802.

Pedersen, P. M., Stig Jørgensen, H., Nakayama, H., Raaschou, H. O., & Olsen, T. S. (1995). Aphasia in acute stroke: incidence, determinants, and recovery. *Annals of neurology*, *38*(4), 659-666.

Sall, J., Lehman, A., Stephens, M. L., & Creighton, L. (2012). *JMP start statistics: a guide to statistics and data analysis using JMP*. Sas Institute.

Sherratt, S. (2007). Multi-level discourse analysis: A feasible approach. *Aphasiology, 21*, 375–393. http://dx.doi.org/10.1080/02687030600911435.

Sherratt, S., & Bryan, K. (2012). Discourse production after right brain damage: Gaining a comprehensive picture using a multi-level processing model. *Journal of Neurolinguistics, 25*, 1–27. http://dx.doi.org/10.1016/j.jneuroling.2012.01.001.

Wright, H. H. (Ed.). (2011a). Discourse in aphasia [Special issue]. *Aphasiology, 25*. Retrieved from http://www.tandfonline.com/toc/paph20/25/11

Wright, H. H. (2011b). Discourse in aphasia: An introduction to current research and future directions. *Aphasiology, 25*, 1283–1285. doi:10.1080/02687038.2011.613452

Wright, H., & Capilouto, G. J. (2012). Considering a multi-level approach to understanding maintenance of global coherence in adults with aphasia. *Aphasiology, 26*, 656–672. doi:10.1080/02687038.2012.676855

Wright H. H., Koutsoftas. A. D., Capilouto, G. J., & Fergadiotis, G. (2014). Global coherence in younger and older adults: influence of cognitivie processes and discourse type. *Aging, Neuropsychology and Cognition, 21,* 174-196.

Yorkston, K. M., & Beukelman, D. R. (1980). An analysis of connected speech samples of aphasic and normal speakers. *Journal of Speech and Hearing Disorders, 45*, 27–36. doi:10.1044/ jshd.4501.27.