DYSARTHRIA UNDER A LINGUIST'S MICROSCOPE

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DYSARTHRIA UNDER A LINGUIST'S MICROSCOPE

by

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Abstract

This thesis examines adult dysarthria from a phonetics/phonology perspective. Three types of dysarthria are analyzed; ataxic, mixed (spastic and flaccid), and hypokinetic. The objective in this thesis is to use acoustic analysis to describe what types of linguistic deficit results from dysarthria.

This thesis examines dysarthria with respect to the source-filter theory. It identifies dysarthria as a source problem resulting in a suprasegmental impairment across all dysarthric types. The two prevalent problems are poor phonation and low pitch levels. Two out of the three clients also exhibit problems with rhythm. Linguistically, dysarthria is a problem that impairs prosody. From the analysis gathered in this data, there appears to be few segmental (or filter) problems. Even the absence of aspiration on the initial voiceless stop can be a source problem, since normal aspiration requires intensity of an aperiodic (noise) source. However, this is not to say that misarticulations do not exist in dysarthric clients. Implications for intelligibility and treatment are discussed.

Table of Contents

List of Appendices

List of Graphs

List of Tables

Acknowledgments

"If you have knowledge, let others light their candles at it."
-Fuller

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Chapter 1 Introduction

1.0 *Scope and Objectives*

This thesis will analyse adult dysarthria from a phonetics/phonology perspective.[1] Dysarthria is an execution disorder which is due to an impairment of motor control and of the integration of the sensory and motor components (Moore, Yorkston, & Beukelman, 1991, p. 185). Regardless of its etiology or specific type, dysarthria is a motor impairment. Each form of dysarthria has its distinct properties; nevertheless there seems to be a common ground in all dysarthric types.

The objective in this thesis is to use acoustic analysis, and observation of transcripts and tapes prepared by the author to describe what types of linguistic deficit results from dysarthria (see Appendix D and E). This thesis will linguistically define dysarthria.

Linguistic theory has been fruitfully applied to other areas of speech language pathology. It is anticipated that the linguistic analysis will also help suggest new treatment options for clients with dysarthria.

This thesis will analyse data from three adults with dysarthria, stemming from different etiologies. (The subjects will be referred to as E.C., A.C., and L.C. See sections 3.1.1, 3.1.3, and 3.1.5 for further information.) These subjects were assessed by a Speech Language Pathologist (SLP) in the summer of 1999. The author will examine the inability or disruption of speech as a result of the vocal mechanism being debilitated; specifically, prosodic impairment including pitch, stress, and intonation will be analysed. The author will characterize dysarthria using linguistic analytical tools such as non-linear representations of prosody in order to define dysarthria linguistically: It will be shown that all the dysarthrics studied have similar prosodic impairments.

1.1 ***Theoretical Approach***

Dysarthria is debilitating because it affects prosody, which in turn contributes to the intelligibility of speech. Linguistics, specifically phonetics/phonology, studies the functions prosody serves in a language, yet linguistic concepts have not been applied to dysarthric speech disorders. For this reason, dysarthria will be analyzed from a phonetic/phonological perspective, as defined below.

1.1.1 *Laboratory Phonology*

Traditionally, phonology has not been concerned with aspects of speech production or perception that result from the physical properties of the system. However, recently a new branch of phonology, laboratory phonology, is concerned with just such issues: specifically, how phonetic analysis can illuminate the study of speech sounds. The focus of this thesis is to characterize the dysfunction of prosody, etc., in English dysarthrics (see Table 6.0). In order to accomplish this, a description of how phonetic properties are realized as phonological units such as stress, etc., in English is necessary. Information drawn from all branches of phonetics will be reviewed below in order to characterize dysarthria linguistically.[2] The next section discusses speech production with respect to the source vs. filter theory.

1.1.2 *Source vs. Filter Theory*

A prevalent model that correlates acoustics and articulatory levels is the phonetically-based source-filter theory (Lieberman & Blumstein, 1988, p. 34). The source-filter theory assumes that the source of the sound (for example the larynx), and the filter (such as the supralaryngeal cavity), together makeup sound production (Lieberman & Blumstein, 1988, p. 34-38).

The source-filter theory can be related to the suprasegmental vs. segmental dichotomy in phonology. The source corresponds to phonation and suprasegmentals, whereas the filter corresponds with the segments of speech.

In non-linear phonology, the suprasegmental and segmental units are clearly differentiated. Non-linear phonology assumes the following representations:

(1) Suprasegmental	IP	(Intonational Phrase- domain of rising intonation)
	...	(Intermediate Structure, not shown)
	|	
	F	(stress feet)
	/\	
	σ_s σ_w	(stressed and unstressed syllables (σ))
	/\ /\	
	| μ | μ	(onsets vs. rhymes (μ))
	| | | |	
Segmental	• • • •	(segments (•))

(adapted from Spencer, 1996, p. 147-199). At the suprasegmental level, there is the domain of rising intonation, which is the intonational phrase. Next, is the intermediate structure. Then there are the feet which divide into stressed and unstressed syllables. The syllables are classified as onsets or rhymes. Lastly, at the segmental level, there are the segments. The acoustic correlates of the source-filter theory will now be overviewed.

1.1.2.1 *Phonation*

Phonation is the rapid opening and closing of the vocal folds, powered by the air flow from the lungs (Lieberman & Blumstein, 1988, p. 11-13). In a typical person, before phonation, the larynx is closed and the vocal folds are tense. The air flows out of the lungs up to the vocal folds where pressure begins to build, since the vocal folds are closed. The vocal folds are pushed apart due to the force of subglottal air pressure, letting the air pass through. Since the vocal folds are composed of elastic, stretchy material, the vocal folds are pulled back together due to two forces. The suction that was caused by the air flow released through the glottal constriction (which is known as Bernoulli Effect) and the intrinsic elasticity of the vocal folds themselves serve to close them. In dysarthric speech, phonation is impaired due to muscle damage (see section 2.1.1). The problem stems in the larynx, where the vocal folds have a limited range of movement or have been paralysed. As a result, air passes freely through the vocal folds with limited vibration or even without vocal fold vibration, thus affecting the speech output.

1.1.2.2 *Suprasegmentals and Temporal Characteristics of Speech*

Suprasegmentals and temporal characteristics are discussed in greater detail below. This overview of the suprasegmental and temporal features of English will compare typical vs. dysarthric speech.

1.1.2.2.1 *Suprasegmentals*

The suprasegmentals include pitch (used for stress and intonation), loudness (used for stress and sonority), and paralinguistic voice quality (Nicolosi, *et al.*, 1989, p. 256).

1.1.2.2.1.1 *Pitch and Intonation*

The suprasegmental use of pitch conveys intonation. Pitch is a perceptual correlate; the phonetic connection is the frequency of vibrations of the vocal folds during a voicied segment (Laver, 1994, p. 450). An acoustic correlate is the fundamental frequency, measured in cycles per second (Hz).

Intonation involves changes in pitch throughout an utterance (Spencer, 1996, p. 36). Intonation contours are the tunes in which an utterance is carried. Intonation can also express a variety of other functions: it expresses a range of emotions, such as surprise, boredom, and excitement. It identifies the major units as a clause or sentence; for example, pitch contours are used to convey specific meanings, such as questions vs. statements. Intonation also signifies what is new and what is already known in the meaning of the utterance; it also serves as a personal identity marker, for example, identifying different social groups and occupations (Crystal, 1997, p. 173).

Dysarthric patients typically have little variation in pitch or intonation. Dysarthric speech tends to be monotone. In the research that the author has collected for this thesis, the lack of pitch in each subject's speech is quite apparent (see sections 4.0.1.2, 4.1.1.2, and 4.2.1.2).

1.1.2.2.1.2 *Loudness and Sonority*

Suprasegmentals also include loudness and sonority. Loudness is the perceptual feature whose physical correlate is intensity (Laver, 1994, p. 505). Intensity is measured in terms of decibels (dB).

A related concept, the sonority of a segment, refers to the fullness or resonance of a sound, or the loudness of that sound relative to that of other sounds with the same length, stress, and pitch. Typically the sonority scale, ranging from most sonorous sounds to least sonorous sounds is low vowels, mid vowels, high vowels and glides, liquids, nasals, voiced fricatives, voiceless fricatives, voiced stops, and voiceless stops. Since dysarthric speech is inclined to monoloudness, patients can have difficulty in producing distinct or intelligible sounds due to an inappropriate level of volume placed on a sound. In dysarthric speech the sonority of sounds might not be distinct; hence dysarthric speech would exemplify monoloudness (see section 4.0.1.3).

1.1.2.2.1.3 *Stress*

Suprasegmentals are used to convey 'stress'. Stress is heard when one of two identical syllables is made more prominent, by exaggerating at least one of the phonetic parameters of pitch, loudness, duration, or quality (Laver, 1994, p. 511). In English, phonological stress serves several functions; word stress (lexical stress) is placed on a particular syllable within a word and serves to identify either the word edge or lexical contrasts (récord vs. recórd); contrastive stress on the other hand places focus on a word in the sentence, for example, "No, HE took the book." as compared to "No, he took the BOOK."[3] In addition, the alternating patterns of stressed and unstressed syllables in a word is rhythm, which serves to organize the pronunciation of segments (Spencer, 1996, p. 36). Dysarthric speaker's speech can be monopitch, monoloud, too long or too short in duration; therefore stress and rhythm is abnormal, resulting in less intelligible speech. In this thesis a variety of reading exercises will be used to analyse alternating patterns of stress (see section 1.1.2.2.2.4). However, contrastive stress is not examined.

1.1.2.2.1.4 *Paralinguistic Features*

Suprasegmentals are also used paralinguistically. Vocal paralanguage is conveyed through voice quality or timbre; if this is altered, a meaning change can occur (Crystal, 1997, p. 171). For example in English, a whisper can indicate something secretive, and a breathy voice can imply deep emotion or sexual desire. The operation of the laryngeal, pharyngeal, oral, and nasal cavities can affect voicing quality (Crystal, 1997, p. 171). In dysarthric speech the voice quality tends to be breathy due to muscle impairment; unfortunately this voice quality can inadvertently convey the wrong message. As this example shows, an inappropriate voice quality can be socially stigmatizing; therefore, the problems with dysarthria need to be identified and corrected. However, in this thesis paralinguistic features are not examined since the data is acquired in therapy, where changes in voice quality do not lead to different interpretations of meaning.

1.1.2.2.2 *Temporal Attributes*

Temporal attributes, or timing include duration, rate, continuity or fluency, rhythm and sequence. Timing plays an important factor in the intelligibility of speech; aspects of timing are discussed below.

1.1.2.2.2.1 *Duration*

Duration is the amount of time taken up by a speech event, usually expressed in thousandths of a second (msec)(Laver, 1994, p. 431). A specific segment will often have an intrinsic duration which it must reach before it can be perceived properly. Duration is a phonetic feature; length or quantity is the phonological correlate. Dysarthric speakers might display problems with intrinsic duration; for example, they might substitute [t] for [s]. The dysarthric speaker might produce an alveolar stop instead of a fricative when s/he does not have an adequate air supply; this is because the stop has a shorter duration than a fricative.

1.1.2.2.2.2 *Rate*

Articulation rate describes the tempo of articulating an utterance; it refers to the speed of execution of phonemes, syllables, and words that are uttered within an individual utterance (Laver, 1994, p. 539). In contrast, speaking rate refers to the overall tempo of performance, not only of all utterances, but also the durations of any pauses between the utterances making up the speaking turn. Rate in general is expressed as a number of syllables per second (Nicolosi, *et al.*, 1989, p. 217). In dysarthric speech, rate is impaired; either the speaker rushes the communication because s/he tends to run out of breath, or the speaker slows the communication in an effort to be more intelligible, often producing unintended paralinguistic messages (see section 4.2.1.4).

1.1.2.2.2.3 *Continuity*

Continuous speech is smooth or fluent; it can be defined as a speaking-turn containing no pauses, nor any non-linguistic prolongation of linguistic elements (Laver, 1994, p. 158). Dysarthric speech is not continuous; instead each word is inclined to be isolated, allowing the speaker to focus on each word's production; this contributes to more intelligible speech, but creates an abnormal speech flow (see section 4.1.1.5).

1.1.2.2.2.4 *Rhythm*

Rhythm is defined as the combination of stress and speech rate (Nicolosi, *et al.*, 1989, p. 230). Pitch, loudness, and tempo influence a language's expression of rhythm (Crystal, 1997, p. 171). As mentioned in sections 1.1.2.2.1.3 and 1.1.2.2.2.2, stress and rate are impaired in dysarthric speech, therefore resulting in an unnatural rhythm, which results in less intelligible speech (see sections 4.0.1.6 and 4.1.1.6).

1.1.2.2.2.5 *Sequence*

Sequence is the appropriate linguistic order of sounds or the temporal arrangement of phonemes in proper order for pronunciation (Nicolosi, *et al.*, 1989, p. 237). In phonology, sequence is known as phonotactic constraints. In dysarthric speech, sequence is not necessarily a problem. However, sound substitutions occur, due to the inability of the speaker to produce certain sounds. Therefore, phonotactic constraints might appear to be violated in production because a speaker articulates [tpl] for an /spl/ cluster: for example, "splinter" [tplɪntɚ] for /splɪntɚ/.[4]

1.1.2.3 *Acoustic Correlates of Segments*

Spectrograms depict frequency, intensity, and time, factors which are relevant for showing formant frequencies, monitoring speech samples, and tracking acoustic changes (Lieberman & Blumstein, 1988, p. 51). With respect to dysarthric speech, spectrograms indirectly reveal muscle impairment through abnormal formant frequencies and acoustic measures. In a spectrogram, the formants are displayed as continuous bands of acoustic energy across the frequencies; the more intense the energy, the darker the formant displayed. Vowels can be perceived with only the first two formants, but three are typically used to identify the sound. This thesis will provide an acoustic analyses of dysarthric speech with the use of the Praat computer software program; waveforms, and pitch and formant extractions will be employed (see sections 3.1.2, 3.1.4, and 3.1.6).[5]

1.1.3 *Conclusion*

This thesis will examine and characterize the muscular impairments that affect the articulators and will rely on experimental and perceptual phonetics to do so. How the prosodic framework is debilitated in dysarthric speech will be analyzed in this thesis. The impaired suprasegmentals, particularly pitch, will be discussed (see sections 4.0.1, 4.1.1, and 4.2.1). Finally, this thesis will apply the phonetics analysis discussed above in proposing assessment and intervention strategies.

1.2 *Significance of Research*

Until recently, linguists have left the study of disordered speech to SLPs. SLPs in turn have tended to focus on analysing children's disordered speech alone. As of today not much research has focussed on adult and geriatric disordered speech, even though many people are affected by such disorders. The research in this thesis will concentrate on geriatric dysarthria, with three case studies, one stemming from Parkinson's disease (PD), one from Amyotrophic Lateral Sclerosis (ALS), and one from a cerebrovascular accident (CVA). It will thus contribute to an area that has seen little linguistic attention.

This research is important because so many people are affected by dysarthria: 1% of the American population over the age of 65 has PD, (http://www.parkinsonsdisease.com/pcp/pcp1.htm Oct. 10, 1999). The annual prevalence (number of cases at any given time) of ALS is estimated at 2.5 to 7 persons per 100,000 people worldwide, whereas the incidence (number of new cases within a year) is 0.5 to 2.4 persons per 100,000 (Tandan, 1994, p. 3-4). PD and ALS are both progressive and degenerative diseases which lead to speech impairment. Since geriatric speech disorders such as dysarthria affect a significant proportion of the population, they need to be studied. Finally, stroke (a type of CVA) is the leading cause of death and disability among adults in America each year (Thomas, 1993, p. 1980). It is estimated that several hundred thousand adults are disabled each year due to cerebrovascular accidents which can cause impairments such as dysarthria.

Neurolinguistic and psycholinguistic models agree that dysarthria is probably a relatively 'surface' like (yet debilitating) impairment in the execution of speech. Within linguistics proper, studying dysarthria from a phonetics/phonology perspective is important because dysarthria affects prosody, and prosody in return is crucial to communication. Linguistics, specifically phonetics/phonology, will provide a new perspective on dysarthria through an analysis of prosodic impairment. Linguistic analytical tools will be utilized to classify the symptoms of dysarthria in order to provide a linguistical baseline of dysarthria. This linguistic analysis will suggest new approaches to treatment.

Notes:

1. Clinical terms are defined in Appendix A.

2. The five branches of phonetics are articulatory, acoustic, experimental, perceptual, and applied (Edwards, 1992, p. 4), which will now be defined briefly. Articulatory (physiological) phonetics deals with the production of speech sounds. Acoustic phonetics is the study of speech sounds through waveform properties, such as patterns of periodicity (tone), and aperiodicity (noise). Acoustic phonetics also examines two speech attributes; they are quality and timing (Laver, 1994, p. 26). Experimental phonetics consists of the research methods and laboratory techniques used for studying speech. Perceptual phonetics focuses on how the auditory and sensory systems discriminate and evaluate the intelligibility of speech sounds (Crystal, 1997, p. 145 and Laver, 1994, p. 26-27). Applied phonetics uses information gathered from the other branches to solve practical problems. For the purpose of this study, all five branches of phonetics will be utilized for the study of dysarthria.

3. In the verb *recórd* the aspiration is obligatory in normal English, while the medial /k/ of the noun *récord* is only optionally aspirated. It can be assumed that the subject A.C. would probably fail to produce the normal aspiration of medial /k/ in the verb *recórd*. This is based on her production of the word 'cake' in Graphs 2.2, 2.4, 2.8, and 3.0 where she does not aspirate the initial /k/.

4. International Phonetic Alphabet (IPA) symbols with corresponding English letters and sample words are provided in Appendix B.

5. Praat computer software program is a speech analysis program available on the web (http://www.praat.org).

Chapter 2 Literature Review

2.0 *Dysarthria*

Dysarthria can be defined as difficult and defective speech caused by muscle impairment (Thomas, 1993, p. 589). A person with dysarthria is linguistically competent; s/he can understand reading, writing and verbal language spoken to him/her. However, a dysarthric will have collection of motor speech disorders resulting from an impairment in the muscles of the speech mechanism, due to damage in the central and/or peripheral nervous system (Darley, Aronson, & Brown, 1969, p. 246). In oral communication, such neurological impairment causes paralysis, weakness, or incoordination of the speech musculature. Respiration, phonation, articulation, resonance and/or prosody can also be affected (Nicolosi, Harryman, & Kresheck, 1989, p. 86). Dysarthria is thus classified as any damage that occurs in the neuromuscular system regulating speech, specifically in the fine motor control of speech production, and that results in articulatory disturbances generally associated with abnormal acoustic patterns of speech (Hirose, 1986, p. 61).

Dysarthria needs to be distinguished from apraxia, which is a speech disorder that results from the inability to transmit motor responses. Apraxia, involves faulty programming of movements, and sequences of movements whereas dysarthria does not. Dysarthria also must be distinguished from aphasia which is the inefficient processing of linguistic units (a competence disorder); dysarthria, in contrast, is a motor impairment, not a processing impairment. (Darley, *et al.*, 1969, p. 246).

The following World Health Organization (WHO) model of chronic disease as applied to dysarthria provides not only a clinical explanation of dysarthria, but more importantly a holistic definition of dysarthria which serves to highlight the types of linguistic and sociolinguistic dysfunctions that can be expected.

Table 1.0 Categorization of Dysarthria

	Patho-physiology	Impairment	Functional Limitation	Disability	Societal Limitation
Dysarthria	Interruption or inference of normal physiology and may involve the central of peripheral nervous system.	A neurologic motor speech impairment that is character-ized by slow, weak, imprecise, and/or un-coordinated musculature and may involve respiration, phonation, resonance, and/or oral articulation.	The functional limitation resulting from the motor speech impairment is character-ized by reduced speech intelligibility and rate and by abnormal prosodic patterns.	The disability involves the reduced ability in communica-tion situations that require understand-able, efficient, and natural sounding speech. It involves inability or limitation in performing socially defined activities and roles within a social and physical environment	This is a restriction attributable to social policy or barriers that limit fulfillment of roles or deny access to services or opportunit-ies

(Yorkston, 1996, supplement p. 46)

The above table characterizes dysarthria with respect to five parameters:

pathophysiology describes the physical breakdown in the body. *Impairment* identifies and characterizes dysarthria as a neurological motor speech deficit with slow, weak, imprecise, and/or uncoordinated musculature. *Functional limitation* specifies the key problems of dysarthria as being reduced speech intelligibility, rate, and abnormal prosodic patterns. *Disability* classifies dysarthria as reduced communication abilities that may limit a person socially. *Societal limitation* outlines the social restrictions placed on person with dysarthria.

2.0.1 *Etiologies of Dysarthria*

In this section, seven neurological types of dysarthria will be briefly reviewed. Then the literature on the linguistic deficits which the subjects of this study should display will be overviewed.

2.0.1.1 *Bulbar Palsy*

Bulbar palsy is a lower motor neuron disorder, which results from: a lesion in the cell bodies of the cranial nerve, damage in the peripheral nerve fibers, or impaired transmission across the myoneural junction (nerve ending in a muscle)(Darley, *et al.*, 1969, p.250). A person with bulbar palsy displays signs of hyporeflexia (diminished functions of the reflexes) and muscle flaccidity (the muscles are relaxed and flabby; there is little muscle tone). Depending on which cranial nerve is damaged, there can be weakness in the tongue, lips, velopharyngeal port (concerning the soft palate), mandible, and/or larynx. A person with bulbar palsy is said to have flaccid dysarthria (see section 2.0.2)(Darley, *et al.*, 1969, p. 250-251).

2.0.1.2 *Pseudobulbar Palsy*

Pseudobulbar palsy is an upper motor neuron disorder; there is damage to the pyramidal system (a system in the shape of a pyramid) and to the extrapyramidal system (the system outside the pyramidal tracts of the central nervous system)(Darley, *et al.*, 1969, p. 252). A person with pseudobulbar palsy presents with spasticity (increased tone or contractions of muscles resulting in stiff or awkward movements), loss of skilled movement, and hyperreflexia (the muscles exhibit increased contractions and increased actions of the reflexes). There is a slow and limited range of tongue and lip movement; swallowing is difficult; there is little movement in the soft palate, and impaired emotional control. A person with pseudobulbar palsy is said to have spastic dysarthria (see section 2.0.2)(Darley, *et al.*, 1969, p. 252-253).

2.0.1.3 *Amyotrophic Lateral Sclerosis (ALS)*

ALS (otherwise known as Lou Gehrig's Disease) is an upper and lower motor neuron disorder. It is a slow, progressive, degenerative disorder that targets the motor neurons of the brain and spinal cord and results in impaired speech musculature, flaccidity, spasticity, and hyperreflexia (Yorkston, 1996, supplement p. 47 and Thomas, 1993, p. 90). A person with ALS is said to have mixed (spastic and flaccid) dysarthria (see section 2.0.2). ALS is examined in greater detail in section 2.2.

2.0.1.4 *Cerebellar Disease*

Cerebellar dysfunction may occur as a result of many diseases and conditions, including tumors, trauma, Multiple Sclerosis, degeneration from toxicity of alcohol abuse, and vascular insults (stroke)(Darley, *et al.*, 1969, p. 256). It is important to note that regardless of underlying pathology, conditions affecting the cerebellum all present in a similar fashion as was clearly established nearly a century ago through a series of experiments carried out by Gordon Holmes (Kandel, Schwartz, & Jessell, 1995, p. 544). For the purpose of this thesis, the focus is on cerebellar disease subsequent to vascular insult. Errors in timing, force, range, and direction of movement are exhibited. Muscles are hypertonic (tense), yet flaccid, and voluntary movements are slow and jerky. A person with cerebellar disease has ataxic dysarthria (see section 2.0.2)(Darley, *et al.*, 1969, p. 255). Cerebellar disease will be discussed in greater detail in section 2.3.

2.0.1.5 *Parkinson's Disease (PD)*

Parkinson's disease (PD) is a movement disorder due to damage of the extrapyramidal system (Darley, *et al.*, 1969, p. 257). PD is a chronic nervous disease characterized by tremor, muscular weakness, and rigidity (Thomas, 1993, p. 1439). Muscles are rigid and movements are slow, with limited range and force. Patients with PD develop hypokinetic dysarthria (see section 2.0.2)(Murdoch, Manning, Theodoros, &Thompson, 1997, p.245). PD is reviewed in greater detail in section 2.1.

2.0.1.6 *Chorea and Dystonia*

The motor speech process are disrupted in both chorea and dystonia. Chorea is a motor disorder with quick, irregular, unsustained, random, and unpatterned movements. There are signs of hypertonia (reduced muscle tension) and incoordination. Dystonia in contrast, is a movement disorder characterized by muscle contractions which build up slowly, produce a prolonged distorted posture, and then gradually subside (Darley, *et al.*, 1969, p. 259-261). Patients with chorea and dystonia are said to have hyperkinetic dysarthria (see section 2.0.2).

2.0.2 *Classifications of Dysarthria*

Seven types of dysarthria have been identified: spastic, flaccid, mixed (spastic and flaccid), ataxic, hypokinetic, hyperkinetic chorea and dystonia. Their symptoms are overviewed in the following table. One contribution of this thesis will be to define similarities and differences between dysarthric types from a linguistic standpoint, adding to the non-linguistically orientated definitions given below (see section 4.4 and Table 6.0).

Table 2.0 Speech Characteristics and Physiology of Each Type of Dysarthria

Type of Dysarthria	Speech Characteristics	Physiology
Spastic Dysarthria (Pseudobulbar Palsy)	Imprecise consonants Poor phonation and intonation, monopitch Reduced stress Harsh voice Lack of control of volume, monoloudness Low pitch Slow rate Hypernasality Reduced stress Poor intelligibility in conversation Poor intelligibility of	Poor movement of the tongue Reduced alternating movements of the tongue Poor lip movements in speech Reduced maintenance of palatal elevation description
Flaccid Dysarthria (Bulbar Palsy)	Hypernasality Imprecise consonants Reduced phonation time Monopitch and monoloudness Breathy voice	Poor lip seal Abnormality of lips at rest Abnormality of spread of lips Dribbling Reduced elevation of

Type of Dysarthria	Speech Characteristics	Physiology
Flaccid Dysarthria (Bulbar Palsy)	Nasal emission Audible inspiration Harsh voice Poor intelligibility of repetition Poor intelligibility of description	tongue Abnormality of tongue at rest Poor alternating movements of the tongue
Mixed (Spastic and Flaccid) Dysarthria (ALS)	Imprecise consonants Hypernasality Harsh voice Reduced rate of speech Restriction of pitch, low pitch Poor intonation and phonation, monopitch Phrases short Vowels distorted Monoloudness Excess and equal stress Reduced phonation time Reduced intelligibility of conversation Reduced intelligibility of description	Reduced ability to elevate the tongue Reduced ability to produce lateral movements of the tongue Reduced alternation of lip movement Reduced tongue movement in speech
Hypokinetic Dysarthria (Parkinson's Disease)	Reduced phonation and intonation, monopitch Reduced stress Reduced control over volume, monoloudness Imprecise consonants Inappropriate silences Short rushes Harsh voice Increased rate of speech Reduced phonation time Reduced intelligibility of description Reduced intelligibility of	Reduced ability to elevate the tongue Inadequate tongue movements in speech Reduced alternating movements of the tongue Dribbling

Type of Dysarthria	Speech Characteristics	Physiology
Hypokinetic Dysarthria (Parkinson's Disease)	conversation	
Ataxic Dysarthria (Cerebellar Disease)	Imprecise consonants Excess and equal stress Irregular articulatory breakdown Vowels distorted Harsh voice Poor intonation and phonation, monopitch Monoloudness Reduced rate of speech Reduced intelligibility of conversation Imprecise consonants Intervals prolonged	Poor tongue movement in speech Poor alternating movement of the tongue in speech Poor swallowing Reduced lateral movement of the tongue Reduced elevation of the tongue Poor alternating movements of the lips Poor lip movements in speech
Hyperkinetic Dysarthria (Chorea and Dystonia)	Variable rate Monopitch Harsh Voice Inappropriate silences Vowels distorted Excess loudness variations Phonemes prolonged Monoloudness	

(Information in this table is complied from Enderby, 1986, p. 196-197 and Darley, Aronson, & Brown, 1969, p. 250-260)

The speech characteristics listed in the above table describe more general motor impairments such as imprecise articulation, irregular articulatory breakdown, and vowel distortions (Ackermann, Hertrich, & Scharf, 1995, p. 1525-1253). These are caused by abnormalities in timing, direction, range, and force of the articulatory gestures characteristic of dysarthria. Furthermore, excess and abnormally equal stress, prolongation of phonemes, prolonged intervals of pause, and a slow speech rate are due to a slowness of articulatory movements caused by the dysarthric motor deficit (Ackermann, *et al.*, 1995, p. 1258).

Since the research in this study will examine ataxic, mixed (spastic and flaccid), and hypokinetic dysarthria, the three types of conditions displayed by the clients will now be discussed in more detail.

2.1 *Parkinson's Disease (PD)*

Parkinson's disease (PD) is a chronic nervous disease characterized by a slowly spreading tremor, muscular weakness and rigidity (Thomas,1993, p. 1439). Patients with PD develop hypokinetic dysarthria (Murdoch, Manning, Theodoros, & Thompson, 1997, p. 245). Hypokinetic (hypokinesia) dysarthria is a decrease in motor reactions to a stimulus resulting in defective speech (Thomas, 1993, p. 948). The impaired articulatory speech of a person with PD might also be characterized as bradkinetic (also known as bradykinesia)(Forrest & Weismer, 1995, p. 261). Bradykinesia is extreme slowness of movement which, can impact the articulators (Thomas, 1993, p. 259).

2.1.1 *Vocal Folds*

In subjects with PD, reports show that the vocal folds open more slowly and close more quickly than in normal subjects (Murdoch, *et al.*, 1997, p. 246). This is due to: the inflexibility of the laryngeal muscles which causes greater than normal resistance to the vocal folds when opening, and increased myoelasticity (pertaining to muscles and their elastic tissue), producing rapid retraction of the vocal folds when closing.

It is important to note that detailed waveforms might be able to display this problem by showing waveform 'attacks' (rises in intensity) that are slower (less steep) than normal, and waveform 'decays' (falls in intensity) that are faster (more steep) than normal. However, no waveforms were actually expanded to reveal this information in this thesis.

2.1.1.1 *Intrinsic Muscles*

Whether or not the laryngeal muscles over-hyperfunction or under-hypofunction is still being debated. Hypertonicity in the intrinsic laryngeal muscles results in higher air flow, decreased subglottal pressure, breathiness, low vocal intensity, and limited frequency range in PD (Murdoch, *et al.*, 1997, p. 246). Hypertonicity (hypertonia) is excess abnormal muscular tension (Thomas, 1993, p. 942). Breathiness and hoarseness are features of a hypofunctioning larynx according to some present theories. The result of incomplete closure of the vocal folds during phonation results of a reduction in the force and range of movement in the laryngeal muscles. On the other hand, theories have stated that intrinsic laryngeal muscles in PD are hypertonic, which results in the vocal folds bowing and incomplete glottal closure. Impaired control and coordination of the respiratory and laryngeal musculature have also been reported as accounting for breathiness and hoarseness (Murdoch, *et al.*, 1997, p. 258-264).

In cases where vocal tremors have been noted in patients with PD, the frequency and/or intensity fluctuations can be correlated to the laryngeal tensor muscles or changes in subglottal air pressure (Murdoch, *et al.*, 1997, p. 259).

2.1.2 *Speech Breathing*

Speech breathing in patients with PD is characterized by insufficient pressure generated to support speech; pressure is lost due to disabled downstream valving (the inability to close the airway and allow pressure to build for speech production)(Murdoch, *et al.*, 1997, p. 260). For example impaired velopharyngeal (concerning the soft palate) functioning or lip seal inadequacy can result in a lowering of intra-oral pressure in patients. In addition, nasality can develop due to the deterioration of velopharyngeal control. Imprecise articulation because of low pressure build-up behind the articulators, is also due to lower than normal air pressure (Solomon & Hixon, 1993, p. 308).

2.1.2.1 *Volume Excursion*

Patients with PD exhibit smaller rib cage expansion, an outwardly displaced abdomen position, and smaller lung volume (Solomon & Hixon, 1993, p. 308). The abdomen positioning for Parkinsonian speakers was displaced outwards for the initiation of speech instead of being in the resting position, whereas, for the healthy control subjects the abdomen was close to resting position. The abdomen appears to contribute to the changes in lung volume during speech breathing. Lung volume was smaller but, interestingly, airflow was higher for the PD subjects.

2.1.3 *Misarticulations*

Misarticulations due to neurogenic (originating from nervous tissue) nervous impulses appear to be the most prevalent error productions. Therefore, a phonetic distinctive feature analysis can be applied; this is discussed below in section 2.1.3.1 (Logemann & Fisher, 1981, p. 348-349).

2.1.3.1 *Articulation Analysis*

The Fisher-Logemann Test of Articulation Competence, which tests all of the consonant phonemes of English in prevocalic, intervocalic, and postvocalic positions was administered. Misarticulations are compared with the phonetic features of each targeted allophone. A determination was made upon whether the features of the allophone were produced correctly. The patient's error productions were then characterized. The error production feature characteristics were compared across patients. Consistence of error types across phoneme classes was examined within each patient and compared between patients. Common misarticulations based on phonetic features were classified and grouped. Phonetic rules were derived based on invariable feature changes in the targeted phoneme productions (Logemann & Fisher, 1981, p. 348-349).

2.1.3.2 *Results*

Two hundred misarticulations of Parkinsonian subjects were studied (Logemann & Fisher, 1981, p. 349). Researchers examined phoneme misarticulations and frequency of the phonemic productions.

Table 3.0 Misarticulations of Phoneme Groups of Patients with PD

Phonemes misarticulated	Number of Patients
/k, g/	90
/k, g/ + /s, z/	63
/k, g/ + /s, z/ + /ʃ, ʒ/	43
/k, g/ + /s, z/ + /ʃ, ʒ/ + /ʧ, ʤ/	39
/k, g/ + /s, z/ + /ʃ, ʒ/ + /ʧ, ʤ/ + /p, b/	29
/k, g/ + /s, z/ + /ʃ, ʒ/ + /ʧ, ʤ/ + /p, b/ + /f, v/	21
/k, g/ + /s, z/ + /ʃ, ʒ/ + /ʧ, ʤ/ + /p, b/ + /t, d/	18

(Logemann & Fisher, 1981, p. 349)

The error productions of /k/ and /g/ represent insufficient contact of the back of the tongue to the velum, which results in emission of the air stream through the narrowed, constricted passage. Therefore, the /k/ becomes [x] and /g/ becomes [ɣ]. It is interesting to note that the frequency of the misarticulation has nothing to do with the phonological complexity of the segment, since errors are more likely in non-complex phonemes like /k, g/ instead of in more complex segments like /ʧ, ʤ/. This fact argues against dysarthria being a phonological (processing) disorder, since if it were one, the more complex segments would be affected first. This misarticulation represents a change from a stop to a fricative.

Misarticulations of the fricative phonemes are perceived as a reduction in the 'sharpness' of the frication expressed (Logemann & Fisher, 1981, p. 351). The /s/ becomes a distorted /s/, which is perceived as a voiceless blade-alveolar continuant, whose aperture is slightly less constricted than is usual for the /s/. The /z/, /ʃ/, and /ʒ/ error productions were perceived as a reduction in the forced turbulent emissions of the air stream, related to an apparent decrease in the degree of constriction of the aperture through which the air stream is passed.

The labial fricative /f/ converting to [p] and /v/ becoming [b], appears to be the result of a reduction in friction (a continuant change)(Logemann & Fisher, 1981, p. 351).

2.1.3.3 *Summary*

The above descriptions illustrate the incomplete contact of the articulators; phonemes are simplified as a result, causing the Parkinson's patients to exhibit reduced understandability (Logemann & Fisher, 1981, p. 352). While the errors can be analysed using features (as Logemann & Fisher do), it is probably wrong to do so. The PD patients are merely misarticulating [-cont] segments, for example, they are not substituting [+cont] for [-cont]. It appears that the misarticulations are related entirely to an alteration of neuromuscular control of the articulators rather than a change in the phonological structures of the patients.

2.1.4 *Acoustic Deficits*

Perceptual qualities of the speech disorder in PD include; reduced loudness, hoarse and breathy voice, monotone pitch, short rushes of speech, and loss of prosodic elements (Murdoch, *et al.*, 1997, p. 246). Hertrich & Ackermann (1993, p. 285) reported monopitch, reduced stress, and monoloudness as the most salient characteristics of PD dysarthria. Focusing on fundamental frequency (f_o), patients with PD exhibit a reduced f_o

range across sentences.

The study of Murdoch, *et al.* (1997, p. 263), shows that the most frequent atypical perceptual distinction was hoarseness, glottal fry (a bubbling, cracking type of low-pitch phonation), pitch unsteadiness, and breathiness. These voice qualities can be contributed to insufficient vocal fold movement. Fundamental frequency in Parkinsonian speech varies from lower pitch to higher and some f_o within normal limits. According to the classical symptoms of hypokinetic dysarthria, low pitch is a frequent perceptual characteristic (Murdoch, *et al.*, 1997, p. 260). Parkinsonian patients demonstrate high glottal resistance and low subglottal pressure which means rigid intrinsic laryngeal muscles and inadequate valving; therefore resulting in communication difficulties.

2.1.4.1 *Results*

From the recorded speech samples, f_o, sound intensity, and durations, were examined (Hertrich & Ackermann, 1993, p. 286-293). Prosodic impairment was based on perceptual judgement of pitch. A hoarse speech quality can mask the f_o spectrum. Articulatory imprecision can impair the listener's recognition of syllabic structure, consequently contributing to the impression of monotonicity. With respect to pitch levels as a whole, male subjects increased whereas female subjects decreased. Pitch accent height, corresponds appropriately to the standard values measured in normal declarative sentences. The speaking rates of the subjects appeared to be within normal range (with the exception of one subject). A significant characteristic of the subjects with PD, was an increase in the length of vowels.

Patients with PD appear to exhibit an 'undershooting' of movements (Hertrich & Ackermann, 1993, p. 295). Hypokinesia of articulatory movements appear to result in short, incomplete stop consonant closure. People with PD are characterized by a generalized loss of linguistic prosody. To conclude, patients with PD appear to illustrate disturbed motor control.

2.1.5 *Temporal Alterations on Speech Intelligibility*

It has been noted that in some cases of PD, the speaking rate of dysarthric speakers is so rapid that it impairs intelligibility (Hammen, Yorkston, & Minifie, 1994, p. 244). Overall, when a patient's speech incorporates a repair strategy to accommodate a motor deficit, such as increased pause durations, rate reductions occur.

2.1.5.1 *Temporal Alternations Experiment*

This study examined speech alterations through paced or synthetically synthesised speech (Hammen, *et al.*, 1994, p. 245). In paced speech, the subjects were asked to produce speech at slower rates than their accustomed productions. In synthetically altered speech, the recorded samples were acoustically analyzed and manipulated to increase speech and/or pause durations.

2.1.5.2 *Results*

It was noticed that the paced speech was significantly more intelligible than the patient's standard speech (Hammen, *et al.*, 1994, p. 252). On the other hand, synthetic speech was not found to be more understandable than habitual (typical) speech. It is important to note that this conclusion is only based on one method of computer synthesis, however; another method may result in more intelligible speech. The results suggest, that in addition to the overall changes in the temporal realm, improvements at the segmental level are also responsible for the increased intelligibility.

2.1.6 *Lower Lip and Jaw Movement*

According to Forrest & Weismer (1995, p. 261-262), lower lip and jaw movement in PD patients might effect stress contrasts. The parameters assessed were peak displacement, peak velocity, and duration. Changes in these areas were monitored as a function of stress in CV syllables. The central aspect of this study was to correlate kinematic parameters with amplitude displacement (the range of motion once the highest and lowest positions are removed) of stress production. Kinematics is the branch of biomechanics concerned with the movement of body parts, without regarding the forces that cause the movements to occur (Thomas, 1993, p. 1055).

2.1.6.1 *Experiment*

The patients participated in three speech tasks including sentence repetition, alternating stress patterns, and word repetition (Forrest & Weismer, 1995, p. 262-263). The speech samples selected in this study allowed observation of the lips and jaw as primary articulators, in correspondence with stress production. Observation of velocity and stress may provide insights into the control or lack of, in the speech movements of patient's with PD. The speech sample chosen maximized the possibilities of the stress production contrasts.

2.1.6.2 *Results*

The patients with PD demonstrated lower peak velocities on opening gestures, which can be explained by the reduced amplitude of movement (Forrest & Weismer, 1995, p. 265). In closing gestures, the patients with PD illustrated shorter durations. The patients with PD were compared to normal neurological geriatrics, NG. The mildly dysarthric and normal speakers' velocity profiles appeared the same. The only difference between the groups studied was the more severe the dysarthria, the more irregular the velocity profiles, which often consisted of multiple peaks.

The overall outcome of this study suggests that speakers affected by PD experienced less precise control for lower lip and jaw opening (as contrasted with jaw closing)(Forrest & Weismer, 1995, p. 268-271). Opening a gesture involves movement initiation, which is generally impaired in PD; however, closing a gesture need not be controlled in the same manner. The deficiency in opening a gesture might reflect a disruption between the neural commands and the speech musculature.

2.1.7 *Intervention*

In understanding the disabilities of a patient with PD, intervention is examined because it provides evidence for the level of the disorder. McNamara, Obler, Au, Durso, & Albert (1992, p. 39) report on self-monitoring skills encompassed in speech: prearticulatory editing, which arises before an error or unintended utterance, and output monitoring, which takes place after an error has occurred. Output monitoring is also perceived as a repair strategy.

2.1.7.1 *Repair Strategies*

McNamara, *et al.* (1992, p. 39) examines two types of repair strategies: lemma repairs and reformulation repairs. Lemma repairs are word substitutions, which only incorporate lexical access procedures, maintaining the original syntax structure unaltered. Reformulation repairs, on the other hand, alter the sentence structure of the repaired item, usually by adding another idea or phrase.

2.1.7.2 *Results*

McNamara, *et al.* (1992, p. 45-48) conducted a study to explore the links between monitoring, naming, and attentional deficits. Patients with PD appear to have no naming problems but have attentional deficits, thus failing to repair a large number of their speech errors. Only twenty-five percent of the errors were corrected (eleven percent lemma repair strategies and fourteen percent reformulation repair strategies).

A generalization can be drawn that neurobiologic abnormalities which cause PD might also underlie a specific communication disorder manifested by an impairment in the ability to detect speech errors (McNamara, *et al.*,1992, p. 49). The patients with PD used lemma and reformulation repair strategies significantly less than patients without brain damage. Identifying and repairing speech errors can be associated with attentional and self-monitoring capacities; therefore, the errors were not specifically a linguistic impairment.

2.1.7.3 *Lee Silverman Voice Treatment (LSVT) vs. Respiration Treatment (R)*

Ramig & Dromey (1996, p. 798-799) examine designated aerodynamic (the study of air and other gases in motion) and glottographic (graph that measures glottal flow) measures of vocal functions in patients with PD. Two forms of intensive speech intervention were utilized for measuring changes in speech and voice deficits (Ramig & Dromey, 1996, p. 798-799 and Ramig, Countryman, Thompson, & Horii, 1995, p. 1247). LSVT trained phonation and respiration, documenting increased sound pressure levels (SPL), whereas, R manipulated respiration only (Ramig & Dromey,1996, p. 803-804). The clients involved in LSVT made significant short-term improvements in speech and voice characteristics (Ramig, *et. al.*, 1995, p. 1247). The patients implementing the LSVT program were given exercises to increase vocal fold adduction, which increased their vocal intensities (Ramig & Dromey,1996, p. 803). Unfortunately, the clients who adopted the R approach were not able to improve sub-glottal pressure. In fact it appeared that this treatment strategy in some instances was counter-productive (Ramig & Dromey,1996, p. 804). Individuals in the R group with ineffective glottal valving mechanisms simply increased respiratory function (which is not adequate for improvements in sub-glottal pressure for speech).

To conclude, for individuals with PD, it is necessary to practice respiration and phonation simultaneously, in order to increase SPL (Ramig & Dromey,1996, p. 804-805). Therefore, LSVT treatment was useful in aiding patients to achieve a more 'typical' mode of phonation. These clients were able to achieve increased SPL through improved vocal fold adduction and increased subglottal pressure. As the communication skills improved in the LSVT subjects, so did their confidence and attitude (Ramig, *et al.*, 1995, p. 1248).

The psychosocial well-being of individuals with PD impacts on their communication abilities. Unfortunately, the R treatment did not increase the SPL, thus weak phonation continued in clients who sought this treatment protocol (Ramig & Dromey,1996, p. 805). Ramig, *et al.* (1995, p. 1247-1248) noted that both treatment groups improved, but the magnitude and consistency of the LSVT patients was greater. The improvement in their communication skills might reflect the motivational attitudes of the clients. Many researchers believe that motivation is the key in overcoming the obstacles presented in PD.

2.2 *Amyotrophic Lateral Sclerosis (ALS)*

ALS is a syndrome marked by muscular weakness and atrophy (a wasting away or shrinkage of body tissues or organs)(Thomas, 1993, p. 90). There is degeneration of the upper and lower motor neurons of the spinal cord, medulla, and cortex, which results in musculature spasticity and hyperreflexia. Prognosis is very poor for patients, but in some instances patients have remained active ten to twenty years after the disease was diagnosed. Patients benefit from physical, occupational, and speech therapy. Therapy is individualized on the patient's needs and deficits.

The World Health Organization (WHO) model of chronic disease as applied to ALS provides a more holistic definition of ALS:

Table 4.0 Categorization of ALS

	Pathophysiology	Impairment	Functional Limitation	Disability	Societal Limitation
Definition	Interruption of inference of normal physiological and developmental processes or structures.	Loss and/or abnormality of mental, emotional, physiological, or anatomical structure or function, including secondary losses and pain.	Restriction or lack of ability to perform an action or activity in the manner or range considered normal that results from impairment.	Inability or limitation in performing socially defined activities and roles within a social and physical environment as a result of internal or external factors and their interplay.	Restriction, attributable to social policy or barriers (structural or attitudinal), which limits fulfillment of roles or denies access to service or opportunities.

(Yorkston, Strand, & Kennedy ,1996, p. 57)

2.2.1 *Physiologic Deficits*

ALS is a progressive, crippling, motor system disorder with clinical characteristics. ALS presents with three classifying subgroups: bulbar, corticobulbar, and spinal (Langmore & Lehman, 1994, p. 28). The predominant features of the bulbar group was damage to cranial nerve nuclei, specifically lower motor neurons (LMN) in the brainstem (Langmore & Lehman, 1994, p. 30). This group experienced dysarthria, and atrophy (weakness and deterioration) and fasciculation (involuntary contractions or twitching) primarily in the tongue, exaggerated jaw jerk, and pharyngeal gag reflexes. There is a tendency for the limbs to be affected, but to a lesser extent than speech. The major characteristic of the corticobulbar group was damage to the corticobulbar tract (the upper motor neurons (UMN)). Dysarthria, exaggerated jaw jerk, and pharyngeal gag reflexes can all be symptoms. In this scenario limbs appear more involved than speech. The essential characteristic of the spinal group was damage to the anterior horn cells and corticospinal tract innervating the limbs; therefore, both the LMN and UMN are involved. There appears to be no dysarthria, atrophy, or fasciculation, but there are equivocal jaw jerk and pharyngeal gag reflexes. Patients presenting with bulbar and corticobulbar forms of ALS exhibit significantly reduced strength and speed of movement in the orofacial structures (Langmore & Lehman, 1994, p. 30). The tongue appears to be the most severely affected structure in all ALS groups, speed and strength were consistently impaired.

2.2.2 *Acoustic Measures*

Caruso & Burton (1987, p. 80), examined the main acoustic characteristics of ALS, such as stop-gap duration (the time from the end of acoustic energy to the onset of acoustic energy associated with the articulatory release burst for the following sound), voice onset time (VOT), and vowel duration in intelligible ALS speakers. In regards to the stop-gap duration, the ALS speakers were found to demonstrate a lengthened stop-gap that was weak. In addition they exhibited a longer vowel duration. There appeared to be a direct correlation between the stop-gap duration and the vowel length; the longer stop-gap duration corresponded to the longer vowel duration. The ALS speakers displayed a higher variability in their VOTs for voiced consonants then voiceless. This study concluded that aberrant temporal characteristics could result from a slowly moving tongue into and or away from the appropriate articulatory postures, slowly and/or weak laryngeal gestures, or a combination of both (Caruso & Burton, 1987, p. 84).

2.2.2.1 *Voiced verses Voiceless Consonants*

The differences between voiced and voiceless consonants exemplify that tongue movements for voiceless consonants maybe more vulnerable to disruption than similar movements for voiced consonants (Caruso & Burton, 1987, p. 85).[1] In a typically normal speaker's tongue velocity it was found that the tongue moves slower for voiceless versus voiced sounds. On the other hand, for ALS speakers it was discovered that tongue movements for voiced consonants are more vulnerable to temporal disruptions due to the larynx compensating for slow/weak supraglottal gestures. It also might be possible that there is additional freedom for unaffected articulators to compensate for voiced verses voiceless sound productions (Caruso & Burton, 1987, p. 85). In the case of English stops, the tongue and all the active articulators move slower for voicleless (Fry, 1979, p. 135-137).

2.2.2.2 *Phonetic Contrasts*

Certain phonetic contrasts appear to be vulnerable to the degenerative process of ALS. However, there seems to be no universal agreement on the hierarchy of the phonetic contrasts (ie. on which contrasts are more or less likely to be affected). According to J. F. Kent, R. D. Kent, Rosenbek, Weismer, Martin, Sufit, & Brooks (1992, p. 726), there is a hierarchy in the severity of the phonetic contrasts. The most profoundly impacted contrast is the stop vs. nasal one, for example /b/ vs. /m/, followed by alveolar vs. palatal consonants such as /s/ vs. /ç/; next is the presence or absence of a syllable-final consonant, then the initial consonant vs. the initial cluster consonant, for example /s/ vs. /st/, and lastly the stop vs. affricate contrast, for instance /t/ vs. /ʧ/. Physiological or articulatory causes can be attributed to these impaired contrasts. For example, failure or impairment of velopharyngeal function is realized in stop vs. nasal consonant misarticulations. The impairment in the lingual function is reflected in the conflict between alveolar vs. palatal consonants. Impairment in syllable structure is exhibited in the presence or absence of syllable-final consonants and in initial consonant vs. cluster misarticulations. Impairment in manner of articulation is realized in the misarticulation of the stop vs. nasal affricate (a nasalized /tʃ/ and/or /dʒ/) contrast. As intelligibility decreases the mean error rate of these five contrast increases. The less impaired contrasts of the ALS subjects are: initial consonant vs. null, initial voicing, front-back vowels, fricative place, initial /h/ vs. vowel, and long vs, short vowel (Kent, *et al.*, 1992, p. 727).

In contrast to the above study, Riddel, McCauley, Mulligan, & Tandan (1995, p. 310) reported that common contrast errors involved voicing or vowel errors: their study detected a high frequency of error between high vs. low vowels and vowel durations. Physiologically this evidence argues for tongue impairment. Errors in final vs. initial voicing contrasts evidence the laryngeal impairment, thus highlighting that errors in voice contrast occur early in the progression of this disease (Riddel, *et al.*, 1995, p. 311).

2.2.3 *Speaking Rate*

The speaking rate is measured as the number of syllables or words per minute for a given speech sample; it includes articulation time and pause time (Turner & Weismer, 1993, p. 1134). The ALS dysarthrics appear to have a greater dependence on pausing when increasing the speech rate. While the ALS patients can increase their speech rates similarly to that of normal speakers, there is a discrepancy when reducing the speech rate. The ALS subjects tend to have an easier time slowing down their speaking rate, thus tending to speak more slowly than a healthy individual. Slow speech might help in achieving more accurate speech productions (Turner & Weismer, 1993, p. 1141-1143).

2.3 *Cerebellar Disease*

Cerebellar disease refers to a diverse group of conditions which share a common anatomical location (see section 2.0.1.4). These may be dealt with under a common heading since, as previously stated, they tend to present with similar symptoms. Cerebellar disease subsequent to vascular injury is usually ischemic and most commonly results from an arterial infarction or blockage.

The neocerebellum is of specific interest to speech, and this part of the organ appears to develop the latest in the evolutionary series. The cerebellum is one of the seven major subdivisions of the brain. It is composed of a small semicircular mass of neural tissue located within the base of the skull just posterior to the brainstem. The cerebellum plays a vital role in synergic control of the skeletal muscles and plays an important role in the coordination of the voluntary muscular movements (Thomas, 1993, p. 350-351). The cerebellum is interrelated with brain stem structures that execute a variety of movements (such as running, walking), and fine voluntary movements as required in writing and playing musical instruments. It controls the property of movements, such as speed, acceleration, and trajectory.

With respect to dysarthric speech the cerebellum functions in motor performance to coordinate the commands issued by the motor cortex. If damage occurs to the cerebellum, then movement control is impaired; higher centers receive gross patterns of motor commands, but lack fine adjustments in time and positioning. Damage interrupts the entire act or sequence of movements; there is evidence of a breakdown in temporal relationships of movements (Kent, *et al.*, 1979, p. 644). Therefore, damage to the cerebellum will result in a communication breakdown due to the motor impairment.

2.3.1 *Acoustic Characteristics*

The speech patterns of cerebellar disease display three characteristics: articulatory inaccuracy, prosodic excess (based on four dimensions excess and equal stress, prolonged phonemes, prolonged intervals, and slow rate), and phonatory-prosodic insufficiency (incorporates the dimensions of monopitch, monoloudness, and harsh voice)(Kent, *et al.*, 1979, p. 628). The articulatory inaccuracy category includes imprecise consonants, irregular articulatory breakdown, and distorted vowels. These errors were attributed to problems in individual movements and dysrhythmia. Dysrhythmia is characterized by prolongations, hesitations, and repetitions that disrupt the flow of speech (Nicolosi, *et al.*, 1989, p. 88). Prosodic excess includes excess and equal stress, prolonged phonemes, prolonged intervals, and slow rate (Kent, *et al.*, 1979, p. 628). These are the outcome of slow individual movements and slow repetitive movements. Phonatory-prosodic inadequacy includes monopitch, monoloudness, and harsh voice. Consequently this is due to the presence of hypertonia (which is excess tension in a muscle). Patients with cerebellar disease tend to exhibit ataxic dysarthria. Their fundamental frequency tends to be flat (monotone). There appeared to be a longer segment duration, which signifies the problem with timing control.

2.3.2 *Timing*

Ackermann & Hertrich (1997, p. 321) make the analogy that the cerebellum is an internal clock that provides the temporal computations in motor, perceptual and cognitive realms. Speech production requires the temporal harmony of the respiratory, laryngeal, and orofacial muscles. Voice onset time (VOT) is an important measure for the timing of the orofacial and laryngeal occurrences. VOT is also an important parameter for phonological information; therefore, it is important that this durational feature is controlled. There appear to be considerable voicing errors in the speech of patients with cerebellar vascular disease (particularly a substitution of an unvoiced sound for a voiced one). A reduced velocity was found in most orofacial movements too.

2.4 *Summary*

PD, ALS, and Cerebellar Disease are three different etiologies which can result in three different types of dysarthria. Dysarthria stemming from PD is associated with inadequate muscle movements of the articulators. As the disease progresses, the patient's speech intelligibility tends to decrease. Dysarthria resulting from ALS is associated with decreased range, rate, and strength of the articulatory movements of the tongue and oropharyngeal musculature (Mulligan, Carpenter, Riddel, Delaney, Badger, Krusinski, & Tandan, 1994, p. 496). The outcome is a progressively decreasing intelligibility of speech. Dysarthria developing from a Cerebellar Disease is associated with fine motor problems (timing and positioning). The outcome is poor speech intelligibility due to a motor impairment.

Linguistically, dysarthria stemming from any etiology, is expected to result in some form of a prosodic impairment. This thesis anticipates prosodic impairments ranging from abnormal pitch, poor phonation and rhythm, to monotonicity.

Notes:

1. In this thesis, the author is using an emic definition of voicing. The notion of voiced/voiceless is something of a misnomer for the phonological contrast in English plosive stops, since such etic features as duration, intensity, and VOT all seem equally important in the phonetic realization of this emic contrast in English. The reader will note that in the contrasting Graphs 2.2 and 2.3, 2.4 and 2.5, 2.8 and 2.9, and 3.0 and 3.1, the subject A.C. does not aspirate her initial voiceless stop /k/ in the word 'cake', yet the listener still perceives the /k/.

Chapter 3 Speech Analysis

3.0 *Methodology*

This section will examine the speech of E.C., A.C., and L.C. through three methods of analysis: acoustic measures of pitch, intensity, and formant frequencies. The analysis will begin by examining each client's 'sing song' production of [a]. In a 'sing song' production the client's pitch is supposed to vary from low to high as in a musical scale. A 'sing song' production of [a] was used in order to identify each client's pitch range ability and to find his/her optimal pitch. This thesis will also analyse an isolated word or phrase form each client in order to illustrate his/her prosodic impairment.

The first analysis will examine the pitch of each client's production of [a]. In the case of dysarthric speech, pitch will identify vocal characteristics such as pitch breaks and monotonicity.

The second analysis will examine the intensity of each client's production of [a]. In speech, the intensity is the rate at which the energy is generated by the vocal folds. If intensity is affected it is most likely a result of muscle impairment due to the type of disease that the client has rather than due to his/her dysarthria.

The third analysis will examine the formants of each client's production of [a]. Formants are especially important when examining vowels, since the first three formants can be used to identify a vowel. In dysarthric speech, formants might have temporal gaps or sudden changes in formant frequency; the formant lines can be tremolo or broken, which is an attribute of poor phonation.

The speech of E.C., A.C., and L.C. will also be compared to the speech elicited from a typical American female/male speaker.[1] The speech from the typical speakers will be analyzed in the same way as the dysarthrics' speech. The analysis will then be compared to each dysarthric subject's speech.

3.0.1 *Equipment*

The speech analysis for this thesis was done with the Praat software program. Speech was recorded on three ninety minute Maxwell UR cassettes with the use of a Sony TC-142 cassette recorder. Speech was then inputted into a computer through a shielded audio cable. The signal was recorded by the computer's sound recorder and then analyzed through Praat's program.

3.0.2 *Transcription*

Transcription includes what was supposed to be said (intended speech) vs. what was said (actual speech). A dictaphone was used to transcribe each tape, looking for segmental errors. The transcription showed virtually no segmental errors; instead there was a prosodic impairment. (The data transcription is provided in Appendix D.) In the rhythm transcription, stress was examined. Two subjects placed additional stress on function words such as 'a' and 'the'. (The rhythm data is provided in Appendix E).

3.1 *Background Information and Speech Analysis*

This thesis will analyze data from three adults with dysarthria stemming from Cerebellar Disease, ALS, and PD. The subjects will be referred to as E.C., A.C., and L.C. subjects were assessed by a SLP in the summer of 1999. The subjects' medical history, reviewed below, was provided by a SLP.

This thesis will also analyse data from a typical American female and male speaker. The female subject is 24 years old with no speech impairment or health problems. The male subject is 27 years old with no speech impairment or health problems. Both speakers are from the same geographical and dialect region as the dysarthric subjects. In this thesis, the data acquired from the typical American speakers will be used as a guideline for comparing typical vs. dysarthric speech.

The fundamental pitch, intensity, and formants for each client will be examined and described. The production of [a] will be analyzed in order to graphically represent each client's vocal characteristics. The prosodic feature of fundamental pitch will be examined through the pitch extraction analysis. During typical speech the prosodic content of a message, which is largely determined by the perceived pitch as a function of time, signals the end of the production (amongst other things)(Lieberman & Blumstein, 1988, p. 199). In typical speech the fundamental pitch (f_0 in Hz) and the overall amplitude (dB) both fall at the end of ordinary statements (affirmatives). Additional speech productions that will illustrate each client's analysis will also be included.

The analysis of speech will begin with the only male subject, E.C., and then continue with the two female subjects, A.C. and L.C. For each client an acoustic and written descriptive analysis of his/her speech will be provided. Additionally, acoustic graphs analyzing the speech of a typical male/female speaker will also be provided.

3.1.1 *Background Information on Subject E.C.*

E.C. is a 65 year old male who has had a brain stem infarct (see section 2.3). The client's primary complaint is one of slurred speech and problems with swallowing. He presents with severe ataxic dysarthria (see Table 2.0).

3.1.1.1 *Clinical Impression*

E.C. is alert and oriented. His cognitive skills appear to be intact for his current needs. His attention and concentration are deemed to be well with in norms. Judgement appears to be intact for all testing procedures.

3.1.1.2 *Oral-Peripheral Examination*

Articulator range of motion including labial and lingual musculature revealed mild right facial paresis (partial or incomplete paralysis). However, E.C. was stimulable for symmetrical range of motion of all oral facial musculature for adequate speech production. Oral dysphagia (difficulty in swallowing), was evident by right facial weakness and an inability to control the oral bolus (a mass of masticated food ready to be swallowed) (Nicolosi, *et al.*, 1989, p. 87). The use of an oral bolus is a diagnostic procedure that allows the SLP to evaluate a client's swallowing ability.

Dysdiachokinesis was evident by the reduced proprioception (movement) with right oral motor structures. Articulatory breakdowns were more obvious at the conversational level. However, diadochokinetic rates for /pʌ/, /tʌ/, and /kʌ/ were deemed adequate. Respiration processes were within functional limits for speech and all oral motor voice procedures.

3.1.1.3 *Voice Production and Speech Intelligibility*

E.C.'s conversational speech was characterized by irregular articulatory breakdowns and prosodic abnormalities (see section 2.3.1). His voice was characterized by a harsh component and has a tendency towards monoloudness.

Dysarthria of speech was very evident. However, his speech was intelligible and E.C. was functional for all sustained phonation and word through short phrase level testing procedures (diagnostic exercises ranging from a single word to short phrases that aid in communication assessment).

The primary deviant quality of E.C.'s speech production is the lack of vocal prosody. His voice lacks fluidity of rate. Reduced rhythm and a staccato phonation with inappropriate loudness variability was obvious at the conversation level.

Rate of speech is slower, with articulatory inaccuracies, especially evident on lingual (pertaining to the tongue) sounds.

E.C. also uses inordinately low pitch, especially when he attempts a long utterance. This low pitch, which is sometimes realized as 'vocal fry', contributes to his harsh resonance.

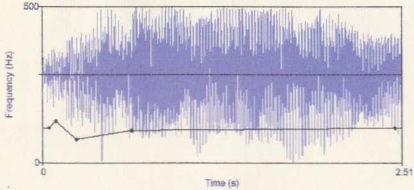
3.1.1.4 *Assessment*

All parameters of voice have been deemed to be mildly to moderately deviant. Prosodic excess, evident by excess and equal stress, prolonged intervals, and abnormal flow of rate, coupled with phonatory prosodic insufficiency (harshness, monopitch, and monoloudness) all contribute to E.C.'s articulatory inaccuracies and dysarthric speech quality (see section 2.3.1).

3.1.2 *Speech Analysis on Subject E.C.*

The following graph shows E.C.'s intended sing-song production of [a]. The graph displays a waveform in the background (drawn in gray) with pitch superimposed over it (drawn in black). The broken line (- - -) through the graph represents the half way mark (250Hz).

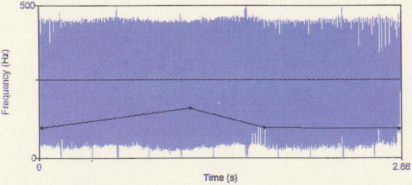
Graph 1.0 E.C.'s Waveform and Pitch Tier of [a]



E.C.'s minimum pitch value is 75Hz, his maximum pitch value is 133Hz, and his average pitch value is 107Hz. In a typical American male, the average frequency of [a] is 124Hz (Peterson & Barney, 1952, p. 183). Therefore, the above graph shows that E.C. exhibits a slightly lower than average pitch. The graph also highlights E.C.'s prosodic impairment as being monotonicity, except at the beginning where E.C.'s pitch rises and then falls immediately. For the remainder and majority of the production he continues at the same pitch level. This illustrates a vocal characteristic of ataxic dysarthria; E.C. is performing consistently with respect to his speech impairment.

For comparison, the next graph shows the waveform and pitch tier of a typical American male producing [a].

Graph 1.1 Typical American Male's Waveform and Pitch Tier of [a]

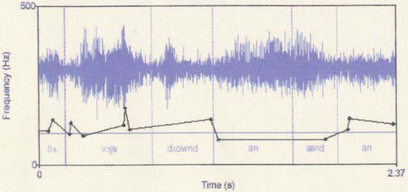


The typical male speaker has a minimum pitch value is 96Hz and his maximum pitch value is 168Hz. His average pitch value is 122Hz which falls within two hertz of what Peterson & Barney (1952) reported as average. In this speech production there is a gradual rise in pitch, then it progressively falls, and levels off, as is supposed to happen in the sing-song production.

The conclusions drawn about E.C.'s pitch and prosodic impairment are reinforced when Graph 1.0 and 1.1 are compared. E.C. does display a slightly lower pitch for a male, and his speech is monotonic.

The following graph shows the waveform and pitch tier of E.C.'s production of the sentence, "the voice droned on and on" [ðʌ vɔjs dɹownd an ænd an].

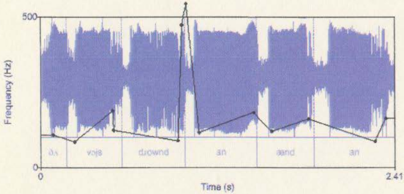
Graph 1.2 E.C.'s Waveform and Pitch Tier



The graph above also illustrates E.C.'s low pitch. E.C.'s pitch average is approximately 109Hz which is consistent with the findings in Graph 1.0.

For comparison, the next graph shows the waveform and pitch tier of a typical American male producing the same sentence that was analyzed above.

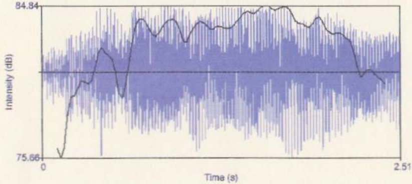
Graph 1.3 Typical American Male's Waveform and Pitch Tier



When the above graph is compared to that of E.C.(see Graph 1.2), the reader will notice that the typical speaker exhibits a higher pitch and a greater usage of the pitch range overall. The typical speaker has a clearly distinct pitch change on each word. In comparison, E.C.'s speech at times had little pitch change, thus identifying him as montonic.

The following graph shows the waveform and intensity of E.C.'s production of [a]. The broken line (- - -) represents the mid point between the minimum and maximum intensities.

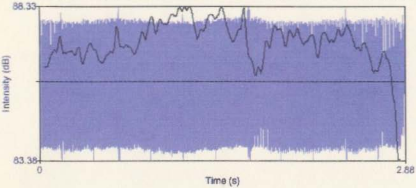
Graph 1.4 E.C.'s Waveform and Intensity of [a]



E.C.'s minimum intensity value is approximately 76dB and his maximum intensity value is approximately 85dB.

For comparison, the next graph shows the waveform and intensity of a typical American male producing [a].

Graph 1.5 Typical American Male's Waveform and Intensity of [a]



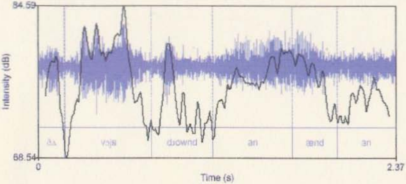
The typical male speaker's minimum intensity value is approximately 83dB and his maximum intensity value is approximately 88dB.

In quantitative terms not much information can not be drawn from Graphs 1.4 and 1.5 since the proper protocol was not used for measuring intensity.[2] E.C. has an intensity range of approximately 9dB, whereas the typical male speaker has an intensity range of 5dB.

Qualitatively, however, there appears to be a difference in the intensity productions of E.C. and the typical male speaker. The intensity in a sing-song production should cresendo and decresendo as does the typical speaker's intensity. There are many more intensity peaks in the typical male speaker's graph which would come across perceptually as an animated production. Therefore, the typical speaker exhibits more control over his realization of suprasegementals, in this case stress.

The following graph shows the waveform and intensity of E.C.'s production of the sentence, "the voice droned on and on" [ðʌ vɔjs dɹownd an ænd an].

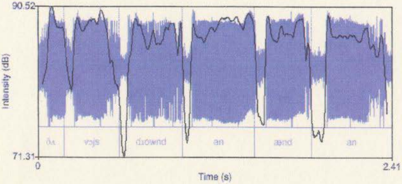
Graph 1.6 E.C.'s Waveform and Intensity



The graph above identifies E.C.'s minimum intensity as approximately 69dB and his maximum intensity as approximately 85dB.

For comparison, the next graph shows the waveform and intensity of a typical American male producing the same sentence that was analyzed above.

Graph 1.7 Typical American Male's Waveform and Intensity



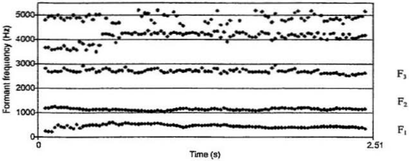
The typical speaker's minimum intensity value is approximately 71dB and his maximum intensity value is approximately 91dB.

Again, quantitatively, little information can be drawn from these intensity values since the proper protocol was not used for measuring intensity. E.C. has an intensity range of approximately 15dB, whereas the typical male speaker has an intensity range of 20dB.

Qualitatively, however, there appears to be a difference in the realization of intensity between E.C. and the typical male speaker. First, there are many more intensity peaks in the typical male speaker's graph, which reinforces the conclusions drawn from Graphs 1.4 and 1.5. Secondly, the peak intensity for the typical male speaker tends to be more level than E.C.'s peak intensity. The typical male speaker tends to speak each word at relatively the same intensity level throughout a speech production. In contrast, E.C. does not appear to have the same control over his intensity as the typical male speaker, and E.C.'s intensity level tends to vary.

The following graph shows E.C.'s formants of [a], which were extracted from a spectrogram.

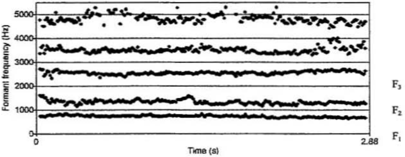
Graph 1.8 E.C.'s Formants of [a]



For a typical American male production of [a] the typical formant frequencies are: F_1 is approximately 730Hz, F_2 is approximately1090Hz, and F_3 is approximately 2440Hz (Peterson & Barney, 1952, p. 183). E.C.'s formant frequencies for his production of [a] are within an acceptable range, though his F_1 seems to average closer to 500Hz than to 720Hz. This signifies that E.C.'s tongue height is lower than that of the typical American male speaker.

For comparison, the next graph shows the formants of a typical American male producing [a].

Graph 1.9 Typical American Male's Formants of [a]



There is little difference between E.C.'s formants and the formants of the typical male speaker. After comparing Graphs 1.4 and 1.5, the reader can safely conclude that E.C.'s articulation of [a] does not appear to be affected by his dysarthria.

3.1.3 *Background Information on Subject A.C.*

A.C. is a 56 year old female diagnosed with Amyotrophic Lateral Sclerosis (ALS) (see section 2.2). Her primary complaint was that of slurred speech and an inability to articulate. She presents with mixed (spastic and flaccid) dysarthria (see Table 2.0).

3.1.3.1 *Conversational Speech*

Conversational speech was significantly reduced in speech intelligibility. It was necessary for A.C. to either write out her communication or to repeat herself.

A.C. was unable to phonate voiceless sounds. In a reading passage she substituted voiced sounds for voiceless sounds (see section 2.2.2.1).

A.C.'s rate of speech was very poor (see section 2.2.3). She had great difficulty in counting from one to twenty. She needed to rest after every two to three number counts.

3.1.3.2 *Respiration*

A significant clavicular breathing pattern was observed (i.e. breathing through the use of accessary muscle, such as the sternocleidomestoid, which raises the collarbone). A.C. needed to take numerous breaths while speaking. She was only able to speak in two to three syllable utterances. The SLP heard audible breathing sounds on inhalation and A.C. often spoke on residual air (the volume of air remaining in the lungs and airways at the end of maximum expiration).

A.C. was not able to phonate any vowels for longer then three to four seconds. Overall, the adverse effect of respiration on speech was deemed to be severe.

3.1.3.3 *Phonation*

Severe tremulous tone with phonation breaks or severe dysphonia characterizes A.C.'s speech production.

Pitch is low and monotone with very abnormal variation. A.C. is not able to imitate the SLP's pitch, nor vary the prosody in her speech.

3.1.3.4 *Vocal Intensity*

A.C.'s ability to be heard was reduced since her vocal intensity is moderately reduced. She was inconsistently able to produce louder sounds at the one syllable utterance level.

3.1.3.5 *Voice Quality and Resonance*

A moderate to severe hypernasality was displayed. A.C.'s voice also had a low, strangled quality. Precision of articulation and severe tension in the laryngeal area compromised her voice quality and resonance.

3.1.3.6 *Vocal Prosody*

Lack of vocal prosody with poor rhythm of speech resulted from A.C.'s incoordination of respiration with phonation. Severe stress and intonation problems during conversational speech were observed.

3.1.3.7 *Assessment*

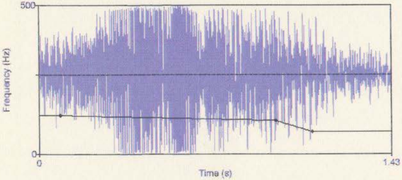
A.C.'s mixed dysarthria includes that of spasticity, slow rate, harsh vocal quality, and overall, general oral motor weakness (see section 2.2.1).

Her voice is characterized by breathiness, often with nasal admission (air escaping through the nasal cavity), reduced audibility, imprecise articulation, monopitch tone, and diplophonia (vibration of the ventricular folds simultaneously with the vocal folds which produces a 'two-toned' voice)(Nicolosi, *et al.*, 1989, p. 284). All range of motion is reduced and pitch and loudness levels were very inconsistent, with reduced variability.

3.1.4 *Speech Analysis on Subject A.C.*

The following graph shows A.C.'s waveform and pitch tier of an intended sing-song production of [a].

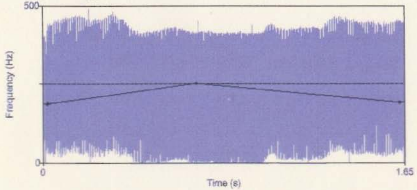
Graph 2.0 A.C.'s Waveform and Pitch Tier of [a]



A.C.'s minimum pitch value is 75Hz, her maximum pitch value is 130Hz, and her average pitch value is 115Hz. In a typical American female the average frequency of [a] is 212Hz (Peterson & Barney, 1952, p. 183). Therefore, the above graph indicates that A.C. exhibits an extremely low pitch for a female. In fact her pitch actually falls into the bottom of the male range. The graph also highlights A.C.'s prosodic impairment as being monotonicity. A.C.'s pitch is relatively level throughout most of her production, with a slight drop which levels off at the end. This illustrates the vocal characteristic of mixed dysarthria; A.C. is performing consistently with her speech impairment.

For comparison, the next graph shows the waveform and pitch tier of a typical American female producing [a].

Graph 2.1 Typical American Female's Waveform and Pitch Tier of [a]

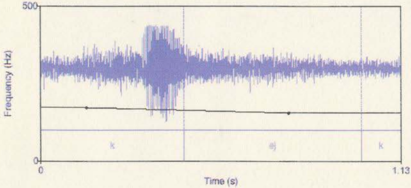


The typical female speaker has a minimum pitch value is 184Hz and her maximum pitch value is 256Hz. Her average pitch value is 215Hz, which falls within three hertz of what Peterson & Barney (1952) reported as average. In this speech production there is a gradual rise in pitch and then it progressively falls, as it should do in a sing-song production.

The conclusions drawn about A.C.'s pitch and prosodic impairments are reinforced when Graph 2.0 and 2.1 are compared. A.C. does display an extremely low pitch for a female, and her speech is monotonic.

The following graph shows the waveform and pitch tier of A.C.'s production of "cake" [kejk], produced in isolation.

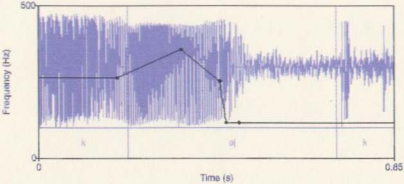
*Graph 2.2 A.C.'s Waveform and Pitch Tier of [*kejk*]*



The above graph reinforces the conclusions that were drawn from Graph 2.0 since both illustrate A.C.'s monotone pitch. A.C.'s average pitch range is 169Hz, or near the top of the male range which is significantly higher than that in Graph 2.0.

For comparison, the next graph shows the waveform and pitch tier of a typical American female producing the word "cake" [kejk].

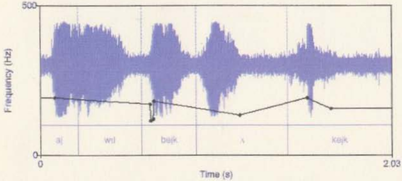
Graph 2.3 Typical American Female's Waveform and Pitch Tier of [kejk]



When the above graph is compared to that of A.C.(see Graph 2.2), the typical speaker exhibits a significantly higher pitch and a greater usage of the pitch range overall. In comparison, A.C.'s speech has relatively no pitch change. Additionally, the initial /k/ of the typical speaker displays a longer duration of high intensity (aperiodic) noise associated with aspiration, which is missing in A.C.'s production of the word 'cake'.

The following graph shows the waveform and pitch tier of A.C.'s production of the sentence, "I will bake a cake" [aj wɪl bejk ʌ kejk].

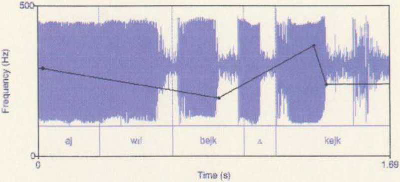
Graph 2.4 A.C.'s Waveform and Pitch Tier



A.C.'s average pitch range is approximately 173Hz (which is significantly higher then what was reported in Graph 2.0, but it is consistent with Graph 2.2; see section 4.1.1.2 for a possible reason for this inconsistency).

For comparison, the next graph shows the waveform and pitch tier of a typical American female producing the same sentence that was analyzed above.

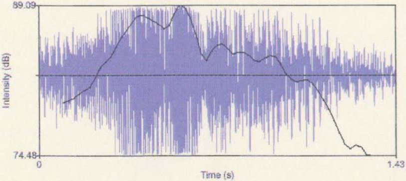
Graph 2.5 Typical American Female's Waveform and Pitch Tier



This graph reinforces the findings in Graph 2.3. The reader will notice that the typical speaker exhibits a significantly higher pitch and a greater usage of the pitch range overall. In comparison, A.C.'s speech has a significantly lower pitch range.

The following graph shows the waveform and intensity of A.C.'s production of [a].

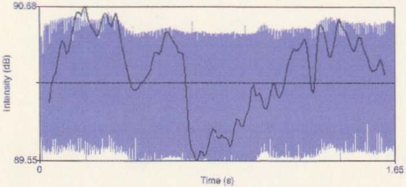
Graph 2.6 A.C.'s Waveform and Intensity of [a]



A.C.'s minimum intensity value is approximately 74dB and her maximum value is approximately 89dB.

For comparison, the next graph shows the waveform and intensity of a typical American female producing [a].

Graph 2.7 Typical American Female's Waveform and Intensity of [a]



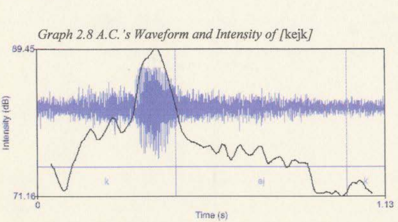
The typical female speaker's minimum intensity value is approximately 90dB and her maximum value is approximately 91dB.

In quantitative terms not much information can not be drawn from Graphs 2.6 and 2.7 since the proper protocol was not used for measuring intensity. A.C. has an intensity range of approximately 15dB, whereas the typical female speaker has an intensity range of 1dB. This discrepancy might be a result of A.C.'s phonation breaks.

Qualitatively, however, there is a difference in intensity between A.C. and the typical female speaker. The intensity in a sing-song production should cresendo and decresendo as does the typical speaker's intensity. There are many more intensity peaks in the typical female speaker's graph which would come across perceptually as an animated production. Therefore, the typical speaker exhibits more control over the suprasegementals, in this case stress.

The following graph shows the waveform and intensity of A.C.'s production of the word "cake" [kejk].

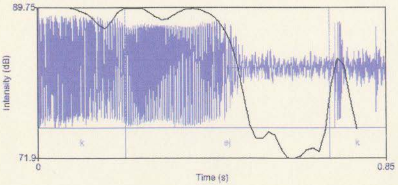
Graph 2.8 A.C.'s Waveform and Intensity of [kejk]



In the above graph, A.C.'s minimum intensity is approximately 71dB and her maximum intensity is approximately 89dB.

For comparison, the next graph shows the waveform and intensity of a typical American female producing the word 'cake' [kejk].

Graph 2.9 Typical American Female's Waveform and Intensity of [kejk]



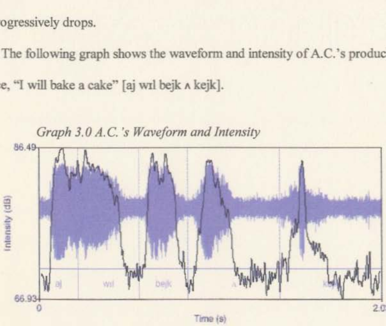
The typical American female's minimum intensity is approximately 72dB and her maximum intensity is approximately 90dB.

Again, quantitatively, not much information can not be drawn from these values since the proper protocol was not used for measuring intensity. A.C. has an intensity range of approximately 18dB, whereas the typical female speaker has an intensity range of 18dB.

Qualitatively, there is a difference in the realization of intensity between A.C. and the typical female speaker. The intensity for the typical female speaker tends to be more level than A.C.'s intensity. The typical female speaker tends to speak at relatively the same intensity level throughout the speech production. In contrast, A.C. does not appear to have the same control over her intensity as the typical female speaker. A.C.'s intensity level progressively drops.

The following graph shows the waveform and intensity of A.C.'s production of the sentence, "I will bake a cake" [aj wɪl bejk ʌ kejk].

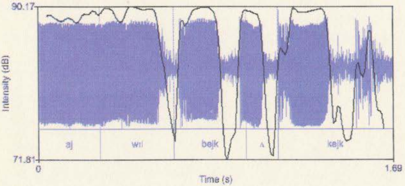
Graph 3.0 A.C.'s Waveform and Intensity



A.C.'s minimum intensity is approximately 67dB and her maximum intensity is approximately 86dB.

For comparison, the next graph shows the waveform and intensity of a typical American female producing the same sentence that was analyzed above.

Graph 3.1 Typical American Female's Waveform and Intensity



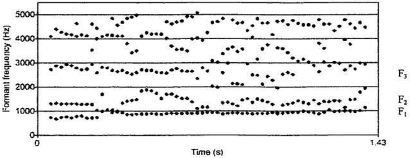
The typical American female's minimum intensity is approximately 72dB and her maximum intensity is approximately 90dB.

Again, quantitatively, not much information can not be drawn from these values since the proper protocol was not used for measuring intensity. A.C. has an intensity range of approximately 19dB, whereas the typical female speaker has an intensity range of 18dB.

Qualitatively, there is a difference in intensity between A.C. and the typical female speaker. The peak intensity for the typical female speaker tends to be more level than A.C.'s intensity. The typical female speaker tends to speak at relatively the same peak intensity level throughout a speech production. In contrast, A.C. does not appear to have the same control over her intensity as the typical female speaker. A.C.'s intensity level appears to follow the same overall intensity pattern as the typical speaker, in that where the typical speaker's overall intensity falls so does A.C.'s intensity. The difference is that A.C.'s intensity is not maintained at a level peak for as long as the typical speaker. A.C.'s intensity also appears to drop more dramatically and stay at a lower intensity longer than the typical speaker.

The following graph shows A.C.'s formants of [a], which were extracted from a spectrogram.

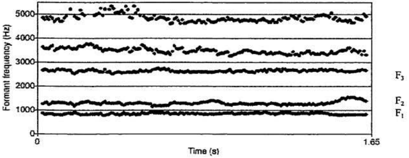
Graph 3.2 A.C.'s Formants of [a]



F_1 and F_2 are close together while F_3 is farther apart. For a female production of [a] the typical formant frequencies are: F_1 is approximately 850Hz, F_2 is approximately1220Hz, and F_3 is approximately 2810Hz (Peterson & Barney, 1952, p. 183). A.C.'s formant frequencies for her production of [a] appear to be within an acceptable range, though her F_2 and F_3 values vary. A.C.'s lowest F_2 value is near 1000Hz while her highest F_2 value is near 2000Hz; on average her F_2 ranges from 1200-1500Hz.

For comparison, the next graph shows the formants of a typical American female producing [a].

Graph 3.3 Typical American Female's Formants of [a]



There is little difference between A.C.'s formants and the formants of the typical female speaker. After comparing Graphs 3.2 and 3.3, the reader can safely conclude that A.C.'s articulation does not appear to be affected by her dysarthria. It is important to note, however, that A.C.'s formants (see Graph 3.2) are very broken up in comparison to the typical female's formants. This might be a result of A.C.'s phonation breaks or her dysphonia. Dysphonia is a partial loss of phonation.

3.1.5 *Background Information on Subject L.C.*

L.C. is a 71 year old female who was diagnosed with Parkinson's disease (PD)(see section 2.1). She reports difficulty with her speech production and swallowing. She presents with hypokinetic dysarthria (see Table 2.0).

3.1.5.1 *Clinical Impression*

L.C. is alert and orientated (ability to comprehend and to adjust oneself in an environment with regard to time, location, and identity of persons). Her cognitive skills appear to be intact for her current needs. Attention, concentration, and judgement are deemed to be within normal limits for all testing procedures. L.C. also presents with a mild hearing loss.

3.1.5.2 *Oral Peripheral Examination*

L.C.'s speech mechanism was normal in size and symmetry. However, her jaw and lateral tongue movements were very dysmetric (inability to fix the range of movements in a muscular activity). Her mandibular range of motion was limited, with left facial weakness (see section 2.1.6).

Articulatory range of motion (including labial and lingual musculature) was moderately reduced in range of motion. However, L.C. was able to be stimulated for symmetrical and improved range of motion in imitation of the speech pathologist.

L.C. showed evidence of dysdiadochokinesis (the inability to execute rapid repetitive movements of the articulators) in the severely reduced proprioception of all oral motor structures (Nicolosi, *et al.*, 1989, p. 79). Her articulatory breakdowns were more obvious at the conversational level. Her diadochokinetic rates for /pʌ/, /tʌ/, and /kʌ/ were deemed inadequate, and her reduced respiration processed further compromised effective phonation for diadochokinetic rates.

3.1.5.3 *Voice Production and Speech Intelligibility*

L.C.'s conversational speech was characterized by irregular articulatory breakdowns and poor prosody abnormalities (see sections 2.1.3 and 2.1.4).

Excessive tension with inspiration (inhalation), leading to tension in the upper chest and laryngeal area was observed (see section 2.1.2).

L.C. presented with extraneous movement of the shoulders and neck and an inappropriate use of breath support. The patient's inability to adequately monitor the amount of air (respiration) required for efficient speech resulted in breathy, unstable delivery and poor vocal intensity (see section 2.1.1.1).

Poor efficiency of phonation resulted in lack of flexibility of laryngeal function and reduced control of the laryngeal movements (see section 2.1.4). These were manifested as:

1. Significantly reduced pitch range.
2. Poor use of pitch intonation
3. Reduced ability to produce desired vocal intensities.
4. Significantly reduced ability to sustain phonation.
5. Poor synchronization of exhalation and speech production.
6. Significantly breathy voice quality with poor vocal intensity.

3.1.5.4 *Articulation*

L.C.'s reduced ability to efficiently use her oral articulators and poor vocal quality detracted from her communicative process. Poor muscular flexibility resulted in unintelligible speech. L.C. needed to repeat herself in order to communicate.

When reciting a reading passage L.C. exhibited a dysfluent and variable rate of speech. She often prolonged phonemes and omitted consonant sounds (see section 2.1.3).

A moderately rapid rate of speech was observed, with progressive acceleration towards the end of speaking phrases (see section 2.1.5). Speech intelligibility was rated as poor to fair for oral reading tasks.

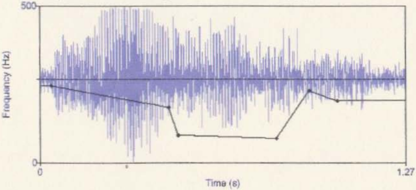
3.1.5.5 *Assessment*

L.C.'s hypokinetic dysarthria is characterized by incoordination and reduced movement of all oral motor articulatory muscles. She presents with uncoordinated respiration (breathing), phonation (voice), articulation (pronunciation), and prosody (rhythm, intonation, rate of speaking). All of these are impaired, causing L.C.'s significant difficulty with speech production and effective communication.

3.1.6 *Speech Analysis on Subject L.C.*

The following graph shows L.C.'s waveform and pitch tier of an intended sing-song production of [a].

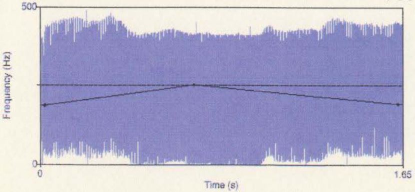
Graph 3.4 L.C.'s Waveform and Pitch Tier of [a]



L.C.'s minimum pitch value is 77Hz, her maximum pitch value is 246Hz, and her average pitch value is 157Hz. In a typical American female the average frequency of [a] is 212Hz (Peterson & Barney, 1952, p. 183). The above graph shows that L.C. exhibits a relatively low pitch on average for a female, however, she is capable of functioning within the typical female range. It is also important to note that in a typical production of [a] the pitch would drop at the end, whereas, L.C.'s pitch gradually declined in the middle of her production and then actually increases towards the end illustrating an unusual pitch pattern. This illustrates a vocal characteristic of hypokinetic dysarthria; L.C. is performing consistently with respect to her speech impairment.

For comparison, the next graph shows the waveform and pitch tier of a typical American female producing [a].

Graph 3.5 Typical American Female's Waveform and Pitch Tier of [a]

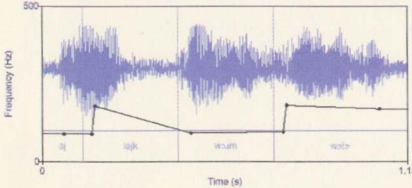


The typical female speaker has a minimum pitch value is 184Hz and her maximum pitch value is 256Hz. Her average pitch value is 215Hz, which falls within three hertz of what Peterson & Barney (1952) reported as average. In this speech production there is a gradual rise in pitch and then the pitch progressively falls.

The conclusions drawn about L.C.'s pitch are reinforced when Graph 3.4 and 3.5 are compared. L.C. does display a low pitch for a female and an usual pitch pattern.

The following graph shows the waveform and pitch tier of L.C.'s production of the sentence, "I like warm water" [aj lajk woɹm wotɚ].

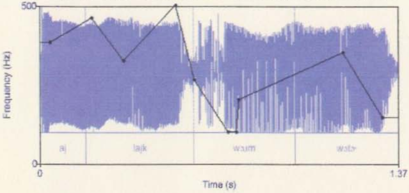
Graph 3.6 L.C.'s Waveform and Pitch Tier



L.C.'s average pitch is approximately 135Hz, which is significantly low. It is interesting to note the pitch of each word, for example, in [aj] and [woɹm] the pitch level is approximately the same monotoned value. L.C. does exhibit some normal peaks in [lajk] and [wotɚ]. However, in her production of [wotɚ] her pitch would be expected to fall since it is the end of a sentence; instead it just levels off. It is interesting to note that if the reader extracts the pitch section for [lajk woɹm wotɚ] and compares it to Graph 3.4, both appear to have the same pitch pattern. It might be that L.C. can only execute one pitch pattern; therefore, she exhibits reduced control of pitch.

For comparison, the next graph shows the waveform and pitch tier of a typical American female producing the same sentence analyzed above.

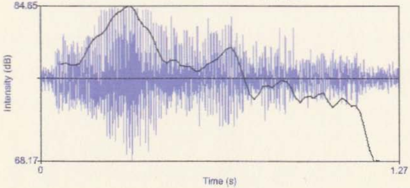
Graph 3.7 Typical American Female's Waveform and Pitch Tier



This graph reinforces the findings in Graph 3.6. The reader will notice that the typical speaker exhibits a significantly higher pitch and a greater usage of the pitch range overall. In comparison, L.C.'s speech has a lower pitch range.

The following graph shows the waveform and intensity of L.C.'s production of [a].

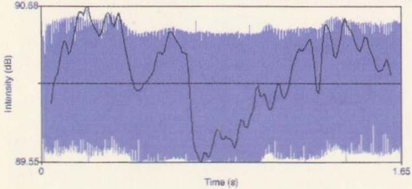
Graph 3.8 L.C.'s Waveform and Intensity of [a]



L.C.'s minimum intensity value is approximately 68dB and her maximum value is approximately 85dB.

For comparison, the next graph shows the waveform and intensity of a typical American female producing [a].

Graph 3.9 Typical American Female's Waveform and Intensity of [a]



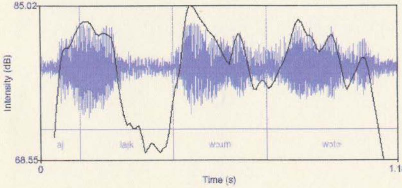
The typical female speaker's minimum intensity value is approximately 90dB and her maximum value is approximately 91dB.

In quantitative terms not much information can not be drawn from Graphs 3.6 and 3.7 since the proper protocol was not used for measuring intensity. L.C. has an intensity range of approximately 17dB, whereas the typical female speaker has an intensity range of 1dB. This discrepancy might be a result of L.C.'s poor synchronization of exhalation and speech production or her intermittent breathiness.

Qualitatively, however, there appears to be a difference in intensity between L.C. and the typical female speaker. The intensity in a sing-song production should cresendo and decresendo as does the typical speaker's intensity. There seem to be many more intensity peaks in the typical female speaker's graph, which would come across perceptually as an animated production. Therefore, the typical speaker exhibits more control over the suprasegementals, in this case stress.

The following graph shows the waveform and intensity of L.C.'s production of the sentence, "I like warm water" [aj lajk wɔɹm wɔtɚ].

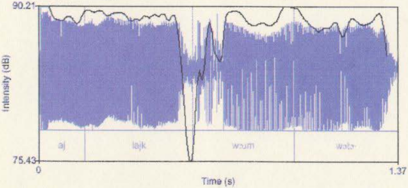
Graph 4.0 L.C.'s Waveform and Intensity



The graph above identifies L.C.'s minimum intensity is approximately 69dB and her maximum intensity is approximately 85dB.

For comparison, the next graph shows the waveform and intensity of a typical American female producing the same sentence analyzed above.

Graph 4.1 Typical American Female's Waveform and Intensity



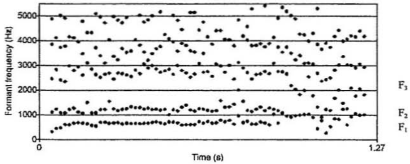
The typical female speaker's minimum intensity value is approximately 75dB and her maximum value is approximately 90dB.

Again, quantitatively, not much information can not be drawn from these values since the proper protocol was not used for measuring intensity. L.C. has an intensity range of approximately 16dB, whereas the typical female speaker has an intensity range of 15dB.

Qualitatively, there is a difference in the realization of intensity between L.C. and the typical female speaker. The typical speaker's intensity is relatively more level throughout the production as it was in her production of the isolates vowel /a/ in Graph 3.9, where an intensity range of only 1dB was observed.

The following graph shows L.C.'s formants of [a], which were extracted from a spectrogram.

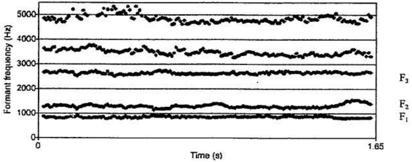
Graph 4.2 L.C.'s Formants of [a]



F_1 and F_2 are close together while F_3 is farther apart. For a female production of [a] the typical American formant frequencies are: F_1 is approximately 850Hz, F_2 is approximately1220Hz, and F_3 is approximately 2810Hz (Peterson & Barney, 1952, p. 183). L.C.'s formant frequencies for her production of [a] appear to be within an acceptable range.

For comparison, the next graph shows the formants of a typical American female producing [a].

Graph 4.3 Typical American Female's Formants of [a]



There is little difference between L.C.'s formants and the formants of the typical female speaker. Therefore, after comparing Graphs 4.2 and 4.3, the reader can safely conclude that L.C.'s articulation does not appear to be affected by her dysarthria. However, L.C.'s formants (see Graph 4.2) appear to break up. This might be a result of L.C.'s reduced ability to sustain normal phonation or due to her breathiness.

3.1.7 *Summary*

As this chapter has shown, acoustic analysis confirms the types of dysfunctions expected for each type of dysarthric. In the next section, the generalizations that can be concluded from this analysis will be discussed.

Notes:

1. The typical American speaker, in this thesis, can be defined as someone who has been born and raised in upstate New York.

2. The proper protocol for measuring intensity includes calibrating the microphone and placing the microphone the same distance away from each subject (Paddock, personal communication, 05/21/00). Calibrating the microphone means inputting different frequencies at the same intensity level. The same response should be elicited from the microphone if the microphone is not biased to any one frequency. There must also be control over the distance from the microphone to the subject's lips. This distance must be constant amongst the subjects.

Chapter 4 Generalizations

This chapter identifies the similarities and differences between three types of dysarthria based on the acoustic analysis from Chapter 3. This information will be presented in the same format as Chapter 1, which utilized the suprasegmental vs. segmental dichotomy (or the source vs. filter dichotomy). The results will then be discussed with respect to this thesis' goal, which is to linguistically define and describe dysarthria. Each client's speech characteristics will be overviewed and then generalizations will be drawn about all three clients.

4.0 *Subject E.C.*

E.C. has ataxic dysarthria which is a result from his CVA. His speech will be divided into two areas for discussion purposes, namely suprasegmental and segmental areas.

4.0.1 *Suprasegmentals*

The prosodic features of the suprasegmentals will be examined; specifically, the phonation, pitch, and stress of E.C.'s speech will be discussed.

4.0.1.1 *Phonation*

Based on the analysis in Chapter 3, E.C.'s phonation appears to be typical. However, the acoustic analysis did not reveal that E.C. has staccato phonation which is impressionistically noted by the SLP and author of this thesis. Furthermore, his voice exhibits vocal fry and vocal harshness which is also noted by the SLP and author of this thesis.

4.0.1.2 *Pitch*

E.C.'s pitch is relatively low for a male since his average pitch value is approxiamtely107Hz as compared to124Hz for a production of [a]. In conversational speech, E.C.'s average pitch is approximately 109Hz, which is still relatively low for a male. Overall, E.C.'s pitch is monotoned (see Graph 1.0).

4.1.2.3 *Loudness*

Unfortunately, intensity could not be accurately calculated quantitatively because the setup protocol for measuring intensity was not followed. However, intensity was recorded the same way for both E.C. and the typical male speaker. Therefore, in comparing their quantitative values some information can be gained. There was only a 4dB difference (x was 4dB louder than y) for the [a] production (Graphs 1.0 and 1.1) and a 5dB difference for the sentence production of 'the voice droned on and on' (Graphs 1.2 and 1.3).

Qualitatively, the typical male speaker appears to have more intensity peaks (Graphs 1.4 and 1.5) and a more level intensity on each peak (Graphs 1.6 and 1.7). Therefore, it appears that the typical male speaker tends to have more control over his intensity level while E.C.'s intensity varies.

According to the judgement of the SLP and the author of this thesis, E.C. does not appear to adjust his intensity appropriately depending on his speaking environment. This means that E.C. might use the same intensity to talk to a person next to him as he would to talk to a person across the room. Therefore, he illustrates monoloudness.

4.1.2.4 *Rate*

Rate is evaluated based on the time it takes E.C. and the typical male speaker to produce the same sentence. (The sentence production task was chosen over the production of [a] because in producing a sentence the speaker's natural rate is better demonstrated. In contrast, in the production of [a], the speaker can either produce the [a] till s/he runs out of breath or s/he can cut it short, without completely using his/her potential breath stream. If the reader compares the time of the sentence productions in Graphs 1.2 and 1.3 or in Graphs 1.6 and 1.7, there is only a difference of three hundredths of a second or 30 milliseconds. Therefore, E.C.'s speech rate appears to be typical.

4.1.2.5 *Continuity*

E.C.'s speech continuity appears to be typical. Based on the impressions of this author upon listening to the tape, E.C. has a natural continuous flow of speech. He does not stop abruptly, pause atypically, or hesitate during speech production.

4.1.2.6 *Rhythm*

E.C.'s speech demonstrates poor rhythm because he has a tendency to place equal stress on every word (see examples in Appendix E). For example, in the sentence 'Yóu dón't méan <u>to</u> téll me <u>that</u> áfter áll this tíme yóu stíll hávèn't fìnished <u>the</u> fírst páge of thát répòrt'; E.C. places additional stress on the underlined words, 'to', 'that', and 'the'. Therefore, his speech has a tendency to sound unnatural.

4.0.2 *Segmentals*

E.C.'s articulation appears to be typical; his speech does not demonstrate any articulation impairment (see transcriptions in Appendix D). This conclusion is supported by comparing Graph 1.8, which displays E.C.'s formants of [a], and Graph 1.9 which displays a typical male's formants. E.C.'s formant frequencies are positioned within a typical range for an [a] production.

4.1 *Subject A.C.*

A.C. has mixed dysarthria which is a result from her ALS. Her speech will be divided into two areas for discussion, segmentals and suprasegmentals.

4.1.1 *Suprasegmentals*

The prosodic features of the suprasegmentals will be examined; specifically, phonation, pitch, and stress of A.C.'s speech.

4.1.1.1 *Phonation*

Phonation for A.C. will be discussed with respect to two areas, voice disorders of phonation and voice disorders of resonance. A.C. experiences phonation breaks (a voice disorder of phonation)(see section 4.2.2). A.C.'s voice may be reduced to a whisper, then disappears, and then returns to normal. Moreover, A.C. experiences dysphonia, which is most likely a result of her ALS (as noted by the SLP). A.C. also displays hypernasality, which is a voice disorder of resonance. (This did not show up in any spectrograms.)

4.1.1.2 *Pitch*

A.C.'s pitch is substantially low for a female since her average pitch value is approxiamtely115Hz as compared to 212Hz for a typical female production of [a] (see Graph 2.0). In conversational speech, A.C.'s average pitch ranges from approximately

169Hz to 173Hz; therefore, there appears to be a huge discrepancy between her speech in isolation vs. her conversation (see Graphs 2.2 and 2.4). Although A.C.'s pitch is still quite low for a female, her pitch is within the male range. It is important to note that her production of [a] occurred during an exercise in the beginning of therapy, whereas her conversational speech sample was taken at the end of therapy. The difference is that in A.C.'s conversational speech her muscles are loose and relaxed since she has been working them for at least the past half hour. As a result, her muscles can manoeuver more regularly and her speech production is at the best for her capability. Since ALS is a disease that causes muscle deterioration, the key is to exercise the muscles regularly; then it will take a longer time for the deterioration to occur. The above observations could explain why A.C.'s pitch range is significantly higher in her conversational speech as opposed to in her production of [a]. However, A.C.'s conversational speech is still monotone, since her average pitch only varies approximately 4Hz (see Graphs 2.2 and 2.4).

4.1.1.3 *Loudness*

Unfortunately, intensity could not be accurately calculated quantitatively because the setup protocol for measuring intensity was not followed. However, intensity was recorded the same way for both A.C. and the typical female speaker. Therefore, in comparing their quantitative values some information can be attained. There was only a 8dB difference for the [a] production (Graphs 2.6 and 2.7), no difference in dB for the word production of 'cake' (Graphs 2.8 and 2.9), and a 1dB difference for the sentence production of 'I will bake a cake' (see Graphs 3.0 and 3.1).

Qualitatively, the typical female speaker appears to have more intensity peaks (Graphs 2.6 and 2.7) and a more level intensity (Graphs 2.8 , 2.9, 3.0, and 3.1). Therefore, it appears that the typical female speaker tends to have more control over her intensity level as opposed to A.C., whose intensity varies.

4.1.1.4 *Rate*

Rate is evaluated based on the time it takes A.C. and the typical female speaker to produce the same sentence. If the reader compares the time of the sentence productions in Graphs 2.4 and 2.5 or in Graphs 3.0 and 3.1, there is only a difference of approximately three tenths of a second or 300 milliseconds. Therefore, A.C.'s speech rate appears to be typical.

4.1.1.5 *Continuity*

A.C.'s speech continuity appears to be typical. Based on the observations of this author, A.C. has a natural, continuous flow of speech. She does not stop abruptly, pause atypically, or hesitate during speech production.

However, the SLP notes that at times, A.C.'s speech tends to be disrupted as if she is focussing on just producing one word at a time. However, if A.C. is made aware of this, she can correct the problem and produce fluent speech.

4.1.1.6 *Rhythm*

A.C.'s speech demonstrates poor rhythm because she has a tendency to place stress on every word (see examples in Appendix E). For example, in the sentence 'I knów I cán wín'; A.C. places too much stress on the both 'I's. Therefore, her speech has a tendency to sound unnatural.

4.1.2 *Segmentals*

A.C.'s articulation appears to be typical; her speech does not demonstrate any articulation impairment (see transcriptions in Appendix D). This conclusion is supported by comparing Graph 3.2 which displays A.C.'s formants of [a] and Graph 3.3 which displays s typical female's formants of [a]. A.C.'s formant frequencies are within a typical range for an [a] production. However, A.C.'s formants appear to break up towards the end of her production; this is a result of her phonation breaks (loss of voice).

4.2 *Subject L.C.*

L.C. has hypokinetic dysarthria which is a result of her PD. Her speech will be divided into two areas for discussion, segmentals and suprasegmentals.

4.2.1 *Suprasegmentals*

The prosodic features of the suprasegmentals will be examined; specifically, phonation and pitch of L.C.'s speech.

4.2.1.1 *Phonation*

L.C. has a reduced ability to sustain normal phonation (see section 4.2.2). Her voice also has a tendency to be breathy, as noted by the SLP and the author of this thesis. This might be the reason for the broken formants in Graph 4.2.

4.2.1.2 *Pitch*

L.C.'s pitch is substantially low for a female since her average pitch value is approxiamtely157Hz as compared to 212Hz for an average production of [a] (see Graph

3.4). In conversational speech, L.C.'s average pitch is approximately 135Hz (see Graph 3.6); therefore, there appears to be a discrepancy between L.C.'s speech in isolation vs. conversation. Although L.C.'s speech is still quite low for a female, in fact, her speech whether it be isolated or conversational is within the male range. It is important to note that her production of [a] was after or part of an exercise that included neck rolls, along with the SLP massaging her muscles during the production, whereas, her conversational speech included none of the above. The difference is that in L.C.'s production of [a] her muscles are loose and relaxed. As a result, her muscles can manoeuver more regularly and her speech production is at the best for her capability. This could explain why her pitch range is higher in her production of [a] as opposed to in her conversational speech. Nevertheless, L.C. still appears to have a reduced pitch range in both productions, and she also appears to use the same rote pitch pattern for all of her speech.

4.2.1.3 *Loudness*

Intensity could not be accurately calculated quantitatively because the setup protocol for measuring intensity was not followed. However, intensity was recorded the same way for both L.C. and the typical female speaker. Therefore, in comparing their quantitative values some information can be attained. There was a 17dB difference for the [a] production of L.C. and the typical speaker (Graphs 3.8 and 3.9), but only a 1dB difference for their sentence productions (see Graphs 4.0 and 4.1). The discrepancy noted in the production of [a] might be due to L.C.'s poor synchronization of exhalation and speech production or due to her intermittent breathiness.

Qualitatively, the typical female speaker appears to have more intensity peaks (Graphs 3.8 and 3.9) and a more level intensity (Graphs 4.0 and 4.1). Therefore, it appears that the typical female speaker tends to have more control over her intensity level, as opposed to L.C. whose intensity shows more variation.

4.2.1.4 *Rate*

Rate is evaluated based on the time it takes L.C. and the typical female speaker to produce the same sentence. If the reader compares the time of the sentence productions in Graphs 3.6 and 3.7 or in Graphs 4.0 and 4.1, there is only a difference of approximately two tenths of a second or 200 milliseconds. Therefore, L.C.'s speech rate appears to be typical.

However, the SLP notes that L.C.'s speech rate can be quite fast at times. If L.C. is made aware of this, she can slow her speech down to a typical rate. L.C. tends to increase her speech rate in order to finish her sentence before she runs out of breath. Her adjustment in rate appears to be a conscious accommodation to her limitations of exhalation.

4.2.1.5 *Continuity*

L.C.'s speech continuity appears to be typical. Based on the observations of this author upon listening to the tape, L.C. has a natural, continuous flow of speech. She does not stop abruptly, pause atypically, or hesitate during speech production.

4.2.1.6 *Rhythm*

L.C.'s rhythmic stress in conversational speech appears to be typical. For example, in the sentence 'Yóu dón't méan to téll me that áfter áll this tíme yóu stíll hávèn't fínished the fírst páge of thát répòrt'; L.C. does not place any undue stress on function words such as 'to' and 'the'. Her speech has a natural rhythm.

4.2.2 *Segmentals*

L.C.'s articulation appears to be typical; her speech does not demonstrate any articulation impairment (see transcriptions in Appendix D). This conclusion is supported by comparing Graph 4.2 which displays L.C.'s formants of [a] and Graph 4.3 which displays the typical female's formants of [a]. L.C.'s formant frequencies are within a typical range for an [a] production. However, L.C.'s formants appear to break up towards the end of her production; this is a result of her reduced ability to sustain normal phonation.

4.3 *Summary*

Each client displays the speech characteristics typical of his/her dysarthric type. E.C. portrays four ataxic dysarthric characteristics: He has a harsh and rough resonance which results in the production of a harsh voice. E.C. has staccato phonation, which is an example of poor phonation. He displays poor vocal prosody, which is an extension of poor intonation; and he demonstrates monoloudness. A.C. portrays three mixed dysarthric characteristics: She is moderately to severely hypernasal. A.C. exhibits severely tremulous speech with many phonation breaks, which is an example of poor phonation. Lastly, she displays an abnormal variation in pitch and is monotoned. L.C. portrays four hypokinetic dysarthric characteristics: She has a reduced ability to sustain normal phonation, which is an example of poor phonation. L.C. has a reduced pitch range. Lastly, she displays poor vocal intensity, which is an example of reduced volume control.

The table below describes each client's speech characteristics identifying which characteristics are a direct result of his/her dysarthric type. The dysarthric types are italicized along with the speech characteristics resulting from the dysarthria. If a speech characteristic is in regular font, it is a more general result of the patient's disease but not a symptom that is specific to speech.

Table 5.0 Speech Characteristics of Each Client

Patient	Dysarthria	Speech Characteristics
E.C.	*Ataxic*	*monoloudness* *harsh/rough resonance* *staccato phonation* *lack of vocal prosody* low pitch and vocal fry reduced rhythm
A.C.	*Mixed (Spastic and Flaccid)*	*moderate to severe hypernasality* *monotone* *abnormal variation in pitch, low strangled sounding* *severe tremulous tone with phonation breaks* severe dysphonia (due to ALS) poor rhythm
L.C.	*Hypokinetic*	*reduced ability to sustain normal phonation; breathiness* *reduced pitch range* *poor pitch inflection* *poor vocal intensity* poor synchronization of exhalation and speech production (due to PD)

4.4 *Generalizations*

The goal of this thesis is to provide a linguistic description of speech characteristics for dysarthria. To do so, this section will be divided into two areas for discussion, suprasegmentals and segmentals.

4.4.1 *Suprasegmentals*

The realization of suprasegmentals reflect what is impaired in the source (the larynx). Dysarthria results from a problem with the source of speech. There are prosodic commonalities across dysarthric types, described below.

4.4.1.1 *Phonation*

Each client has demonstrated abnormal phonation: E.C. has staccato phonation. A.C. exhibits phonation breaks and talks on residual air. L.C. cannot sustain normal phonation; she has a difficult time coordinating exhalation and speech production.

4.4.1.2 *Pitch*

Perceptually, the source problem is identified as an abnormal pitch level and range. Each client's average pitch was lower than a typical speaker. The generally lowered fundamental pitch might be attributable to the fact that 'stiffer' vocal folds present greater resistance to subglottal air pressure, thus delaying the opening for each cycle of the waveform. E.C.'s average pitch was relatively low for a male. Similarly, A.C. and L.C.'s average pitch levels were in the typical male range, which was considerably low since they are both females. Furthermore, E.C. and A.C.'s pitch range was classified as montone while L.C.'s pitch range was reduced.

4.4.2 *Segmentals*

The realization of segmentals reflect what is impaired in the filter. According to observations made earlier, there is little problem with the filter. Each client's dysarthric speech with respect to segment timing, sequence, and articulation is typical. Since there appears to be no real segmental problems, the real communication breakdown appears to reside in the fine motor control of the speech source which affects the suprasegmentals of speech.

The speech characteristics that are similar and different amongst the clients are listed below in Table 6.0. In Table 6.0, pluses (+) and minuses (-) are used: a plus means that the subject experiences this abnormal characteristic/symptom, whereas, a minus means that the subject is functioning typically. (Therefore, the subject does not experience the symptom.)

Table 6.0 A Functional Analysis of Dysarthria

	Symptoms	E.C.	A.C.	L.C.
Segmentals (filter)				
	temporal	-	-	-
	sequence	-	-	-
	articulation	-	-[1]	-[2]
Supra-segmentals (source)				
similarities:	poor phonation	+	+	+
	lowered pitch	+	+	+
	reduced pitch range/ monotonicity	+	+	+
differences:				
	monoloudness	+	-	-
	breathiness	-	-	+
	vocal fry	+	-	-
	dysphonia	-	+	-
temporal differences:				
	poor rhythm	+	+	-
	speech rate	-	-	-[3]
	continuity	-	-[4]	-

Notes: + means that the patient experiences the symptom, whereas - means that the patient does not experiences the symptom.

1. In this study, articulation was found to be within a typical range of production for all clients. A.C. did have a few sounds that were voiced instead of voiceless, for example, /d/ for /t/ and /g/ for /k/. These voicing errors were not consistent, therefore, it appears as if they were just a mistake. See pages 119 and 120 in Appendix D.
2. L.C.'s articulation was also typical. However, in section 2.1.3, misarticulations are discussed for patient's with PD. L.C. is in the early stages of PD and she exercises her muscles regularly in speech therapy. In PD if the muscles are exercised regularly it is more difficult for them to deteriorate. Therefore, L.C.'s articulation is yet to be affected.
3. Overall, L.C.'s speech rate appears to typical. However, she tends to consciously increase her speech rate when she feels she is running out of air. According to Table 6.0, L.C. has difficulty synchronizing her exhalation and speech production, which is due to PD. Therefore, L.C. will adjust her speech rate in order to accommodate to her PD.
4. Overall, A.C.'s speech continuity appears to be typical. At times she tends to have disrupted speech as if she is producing each word in isolation. However, if A.C. is made consciously aware of this, she can produce fluent speech.

As shown in Table 6.0, the three dysarthrics analyzed in this study all share impairments of the source or suprasegmental level. In contrast, they displayed no difficulties at the filter or segmental level. Finally, each dysarthric also displayed individual suprasegmental impairments which were due more to his/her specific type of dysarthric impairment or disease.

These observations both reinforce the validity of the linguistic dichotomy between suprasegmental and segmental levels (see section 1.1.2). Non-linear phonology makes a fundamental distinction between: units which are above the segments (such as stress feet and syllables), which are linearly ordered vs. units which are below the segment (such as features), which are unordered (i.e. pronounced at the same time within a given segment). As shown in this thesis, the real locus of the impairment in dysarthrics is at the suprasegmental level (above the segment). Dysarthrics mainly have problems in their realization of the 'scaffolding' of speech; these observations have implications for treatment, as discussed below.

4.5 *Implications*

Each client has demonstrated a source problem resulting in a suprasegmental impairment common across dysarthric types. Phonation and pitch appear to be the two most prevalent problems. First, if a person cannot phonate properly then s/he can not generate the type of air stream necessary for proper speech. Second, if a person does not have the proper command of pitch level or range then the listener has the burden of deciphering the information, which the dysarthric speaker intended to convey. Both of these suprasegmentals have implications for intelligibility. When phonation and/or pitch is/are impaired, there is a strain on communication interaction because intelligibility has been decreased.

Two universal problems for dysarthria have been identified above (phonation and pitch). Implications for treatment are as follows. First, therapy should focus on source/suprasegmental problems since therapy in this area will address the main problems of intelligibility displayed by all dysarthrics. Second, therapy does have real benefits such as changing the realization of pitch (see sections 4.1.1.2 and 4.2.1.2). The more the speech muscles are exercised, the stronger they remain, and the more intelligible the client stays. In this thesis, all three clients presented with some type dysarthria, yet their intelligibility remained high due to their dedication and motivation to their therapy. Focusing on therapy at the suprasegmental level will give the clients the greatest return for their dedication.

The author wants to address that she has probably overstated the discreteness of the source/filter distinction, as well as the discreteness of the parallel waveform/spectrum and suprasegmental/segmental distinctions. In the antiseptic world of acoustic physics the source is completely independent of the filter, but in the real world of anatomy and physiology the larynx (source) and the pharynx (filter) are not completely independent of each other. This is because of the interconnections between the laryngeal muscles and the pharyngeal muscles, including those extra-lingual muscles that move the root of the tongue. For example, a horizontal tongue tremor indicated by the varying second formant

(F2) of the subject A.C. in Graph 3.2 might be accompanied by a varying fundamental (f_o) heard as a tremulous voice. A study of such source/filter interactions would require at least a Ph.D. thesis.

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Appendix A
Glossary

aerodynamic the study of air and other gases in motion, forces setting them into motion, and results of such motion
(Nicolosi, *et al.*, 1989, p. 4)

Amyotrophic Lateral Sclerosis (ALS) otherwise known as Lou Gehrig's Disease, is an upper and lower motor neuron disorder
(Thomas, 1993, p. 90)

arterial relating to one or more arteries
(Thomas, 1993, p. 150)

bulbar palsy is a lower motor neuron disorder, which results from: a lesion in the cell bodies of the cranial nerve, damage in the peripheral nerve fibers, or impaired transmission across the myoneural junction
(Darley, *et al.*, 1969, p.250)

chorea is a motor disorder with quick, irregular, unsustained, random, and unpatterned movements
(Darley, *et al.*, 1969, p. 260)

clavicular breathing breathing through the use of accessary muscle, such as the sternocleidomestoid, which raises the collarbone

downstream valving the inability to close the airway and allow pressure to build for speech production
(Murdoch, *et al.*, 1997, p. 260)

diplophonia vibration of the ventricular folds simultaneously with the vocal folds which produces a 'two-toned' voice
(Nicolosi, *et al.*, 1989, p. 284)

dysarthria is difficult and defective speech caused by muscle impairments
(Thomas, 1993, p. 589)

dysdiadochokinesis the inability to execute rapid repetitive movements of the articulators
(Thomas, 1993, p. 589)

dysmetric/dysmetria inability to fix the range of movements in a muscular activity
(Thomas, 1993, p. 592)

dystonia is a movement disorder characterized by muscle contractions which build up slowly, produce a prolonged distorted posture, and then gradually subside
(Darley, *et al.*, 1969, p. 259)

extrapyramidal system the system outside the pyramidal tracts of the central nervous system. The functional system including all desending fibers arising in the cortical and subcortical motor centers that reach the medulla and spinal cord by pathways other than recognized pyramidal tracts. The system is important in the maintenance of equilibrium and muscle tone.
(Thomas, 1993, p. 695)

filter an articulatory filter is a supralaryngeal cavity whose resonant frequencies reshape the spectrum of any source to produce the spectral peaks commonly called formants. The two main filters are the nasal cavity and the oral cavity, with the latter often subdivided into the pharynx cavity behind the tongue and the buccal cavity above the tongue.
(Paddock, personal communication, 09/08/00)

flaccidity the muscles are relaxed and flabby; there is little muscle tone
(Darley, *et al.*, 1969, p.250)

formants represent air vibration in the vocal tract characterized on the spectrogram by a dark area indicating high intensity of a group of frequency components. Formants are measured in terms of frequency or Hertz (Hz).
(Nicolosi, *et al.*, 1989, p. 108)

vocal/glottal fry syncopated vocal fold vibration which generally occurs over the lower part of the pitch range: usually described as a bubbling, cracking type of low-pitch phonation
(Nicolosi, *et al.*, 1989, p. 284)

glottographic graph that measures glottal flow
(Ramig & Dromey, 1996, p. 799-802)

hemorrhagic lesion bleeding due to an injury or wound
(Thomas, 1993, p. 881)

hyperreflexia the muscles exhibit increased contractions and increased actions of the reflexes
(Darley, *et al.*, 1969, p. 252)

hypertonia (hypertonicity) is excess abnormal muscular tension
(Thomas, 1993, p. 942)

hyporeflexia diminished functions of the reflexes
(Darley, *et al.*, 1969, p.250)

infarction an occlusion of the suppling artery or a blockage
(Thomas, 1993, p. 982)

inspiration inhalation; drawing air into the lungs
(Thomas, 1993, p. 996)

intensity is the force, energy, power, or pressure acting to produce the sound wave. Intensity is measured in decibels (dB).
(Nicolosi, *et al.*, 1989, p. 133)

ischemic/ischemia lesion local and temporary deficiency of blood supply die to an obstruction of the circulation due to an injury or wound
(Thomas, 1993, p. 1024)

kinematic parameters with amplitude displacement the range of motion once the highest and lowest positions are removed

lingual pertaining to the tongue
(Nicolosi, *et al.*, 1989, p. 153)

myoelasticity pertaining to muscles and elastic tissue
(Thomas, 1993, p. 1263)

myoneural junction ending of a nerve in a muscle
(Thomas, 1993, p. 1265)

nasal admission air escaping through the nasal cavity

neurogenic originating from nervous tissue
(Thomas, 1993, p. 1299)

oral bolus a mass of masticated food ready to be swallowed
(Thomas, 1993, p. 249)

orientated ability to comprehend and to adjust oneself in an environment with regard to time, location, and identity of persons
(Thomas, 1993, p. 1373)

paresis partial or incomplete paralysis
(Thomas, 1993, p. 1438)

Parkinson's disease (PD) is a movement disorder due to damage of the extrapyramidal system
(Darley, *et al.*, 1969, p. 257)

phonation break loss of voice as a esult of hysteria, growths, paralysis, disease, or overuse of the vocal folds (also known as dystonia and aphonia)
(Nicolosi, *et al.*, 1989, p. 284)

phonatory-prosodic insufficiency incorporates the dimensions of monopitch, monoloudness, and harsh voice
(Kent, *et al.*, 1979, p. 628)

phonetics the science concerned with the production and perception of speech sounds (Nicolosi, *et al.*, 1989, p. 200)

phonology the study of language's sound system (Nicolosi, *et al.*, 1989, p. 203)

pitch is the acuteness of a tone, dependent on the frequency, intensity, and overtone of the vocal fold vibrations. Pitch is measures frequency in Hertz (Hz). (Nicolosi, *et al.*, 1989, p. 204)
refers to the periodic fundamental pitch which in speech is determined by the frequency of vibration of the vocal folds
(Denes & Pinson, 1993, p. 176)

proprioception awareness of posture, movement, and changes in equilibrium and the knowledge of the position, weight, and resistance of the objects in relation to the body
(Thomas, 1993, p. 1608)

prosodic excess based on four dimensions excess and equal stress, prolonged phonemes, prolonged intervals, and slow rate
(Kent, *et al.*, 1979, p. 628)

pseudobulbar palsy is an upper motor neuron disorder; there is damage to the pyramidal system and to the extrapyramidal system
(Darley, *et al.*, 1969, p. 252)

pyramidal system a system in the shape of a pyramid
(Thomas, 1993, p. 1650)

residual air volume of air remaining in the lungs and airways at the end of maximum expiration
(Nicolosi, *et al.*, 1989, p. 227)

source the two sources of speech sounds are periodic voice, the normal source of sonorants; and aperiodic noise, the normal source of voiceless obstruents. Note that both sources are combined (occur simultaneously) in voiced obstruents.
(Paddock, personal communication, 09/08/00)

spectrum is a two dimensional display of intensity as a function of frequency
(Paddock, personal communication, 09/08/00)

spasticity increased tone or contractions of muscles resulting in stiff or awkward movements: the result of an upper motor neuron lesion
(Thomas, 1993, p. 1834)

stop-gap duration the time from the end of acoustic energy to the onset of acoustic energy associated with the articulatory release burst for the following sound

(Caruso & Burton,1987, p. 81)

suprasegmentals the prosodic features of a language, such as stress, intonation, duration, and juncture
(Nicolosi, *et al.*, 1989, p. 256)

velopharyngeal port the opening of the soft palate
(Thomas, 1993, p. 2118)

waveform[1] is a graphic representation of a wave illustrating its pattern of intensity, amplitude, or pressure at any moment
(Nicolosi, *et al.*, 1989, p. 290)

waveform[2] is a two dimensional display of intensity as a function of time
(Paddock, personal communication, 09/08/00)

Appendix B
IPA Symbols

This chart represents IPA symbols along with their corresponding English letter and a sample word illustrating the sound in question.

IPA Symbols	English Letters	Words
p	p	pen
b	b	bed
t	t	to
d	d	dog
k	k	cat
g	g	got
m	m	mop
n	n	not
ŋ	ng	ring
θ	th	thin
ð	th	the
f	f	fish
v	v	vase
s	s	sun
z	z	zoo
ʃ	sh	shoe
ʒ	s	measure
ʧ	ch	chair
ʤ	j	just
ɹ	r	rode
l	l	like
w	w	water

IPA Symbols	English Letters	Words
ij	e	we
i	e, ea, ee	eat
ɪ	i, y	it
ej	a	hate
e	a, ai	ate
ɛ	e	end
æ	a	and
aj	i	hide
a	e	we
ʌ	u	up
ʌw	ou	round
ə	o, a, i, e	about
uw	o, ou	to, you
u	oo, u, o	do
ʊ	oo, ou, u	look
ow	o	go
o	o, oa	coal
ɔj	o, oi	coin
ɔ	o, a	cloth
ɝ	er, ur, ir	herd
ɚ	er, or, ar	butter

Edwards, H. (1992). *Applied Phonetics: The sounds of American English*. San Diego, California: Singular Publishing Group, Inc.

Appendix C
Release Form

Release Form

Participant's Name:______________________

I give consent that any information in my file, such as background information, diagnostic assessment results and therapy intervention techniques, may be utilized.

I have been advised:

> I understand that all information provided will be kept strictly confidential and that my identity will only be known to the present researcher. In the research my name will be altered to protect my anonymity.
>
> I understand that the therapy sessions might be tape-recorded. These tapes will only be accessible to the present researcher and her supervisor. These tapes will be stored in a locked, fire proof box in the researcher's home. The researcher is the only person accessible to the key for this box.
>
> I grant permission to use any pertinent information for your current research, which will result in a published or unpublished thesis.
>
> I also understand that my participation is voluntary and I may withdraw from the research at any time.

Participant's Signature:______________________

Date:______________________

Interviewer:______________________

Appendix D
Data Transcription

Transcription format is adopted from DuBois, Cumming, Schwetze-Coburn, & Paolino (1992).

Client: E.C.

Background Information: E.C. presents with ataxic dysarthria. His vocal characteristics consists of low pitch and vocal fry, monoloudness, harsh/rough resonance, reduced rhythm, staccato phonation, and lack of vocal prosody.

Data:
Rainbow Passage

When the sunlight strikes raindrops in the air, they act like a white light and form a
[whɛn ðʌ sʌnlajt stɹajks ɹejndɹʌps ɪn ðʌ eɹ ðej ækt lajk ʌ wajt lajt ænd fɔɹm ʌ
rainbow. The rainbow is a division of white light into many beautiful colors.
ɹejnbow ðʌ ɹejnbow ɪs ʌ d ɪv ɪʒʌn ʌv wajt lajt ɪntuw mʌnij bjuwtɪful kʌlɚs
These take the shape of a long round arch, with its path right above and its
ðijz tejk ðʌ ʃejp ʌv ʌ lɔŋ ɹʌwnd ʌɹʧ wɪθ ɪts pæθ ɹʌjt ʌbʌv ænd ɪts
two ends apparently beyond the horizon.
tjuw ɛndz ʌpejɹɪntlij bijʌnd ðʌ hɔɹajzʌn]

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two ends apparently beyond the horizon. There is according to legend a boiling
tjuw ɛndz ʌpejɹɪntlij bijʌnd ðʌ hɔɹajzʌn ðeɹ ɪs ʌkɔɹdɪŋ tuw lɛgʌnd ʌ bɔjlɪŋ
pot of gold at one end. People look but no one ever finds it. When a man looks
pʌt ʌv gowld æt wʌn ɛnd pijpəl lʊk bʌt no wʌn ɛvɚ fajns ɪt whɛn ʌ mæn lʊks
for something beyond his reach his friends say he is looking for the pot
fɔɹ sʌmθɪŋ bijʌnd hɪs ɹijʧ hɪs fɹijən..hɪs fɹɛnds sej hij ɪs lʊkɪŋ fɔɹ ðʌ pʌt
of gold at the end of the rainbow.
ʌv gowld ʌt ðʌ ɛnd ʌv ðʌ ɹejnbow]

When the sunlight strikes raindrops in the air, they act like a white light and form a
[whɛn ðʌ sʌnlajt stɹajks ɹejndɹʌps ɪn ðʌ eɹ ðej ækt lajk ʌ wajt lajt ænd fɔɹm ʌ
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for something beyond his reach his friends say he is looking for the pot of gold at
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the end of the rainbow.
ðʌ ɛnd ʌv ðʌ ɹejnbow]

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the end of the rainbow.
ðʌ ɛnd ʌv ðʌ ɹejnbow]

The actual primary rainbow observed is said to be the affect of
[ðʌ ækʃuwl pɹajmeɹij ɹejnbow ʌbsɚvd ɪs sɛd tuw bij ðʌ ʌfʌkt ʌf
superposition of a number of bows. If the red of the second bow falls
suwpɚpʌzɪʃʌn ʌv ʌ nʌmbɚ ʌf bows ɪf ðʌ ɹɛd ʌv ðʌ sɛkɪn bow fɔls
upon the green of the first, the result is to give a bow with an abnormally
ʌpan ðʌ gɹijn ʌv ðʌ fɚst ðʌ ɹijsʌlt ɪs tuw gɪv ʌ bow wɪθ æn æbnɔɹmʌlij
wide yellow band.
wajd jəlow bænd]

If the red of the second bow falls upon the green of the first, the result is to
[ɪf ðʌ ɹɛd ʌv ðʌ sɛkɪn bow fɔls ʌpan ðʌ gɹijn ʌv ðʌ fɚst ðʌ ɹijsʌlt ɪs tuw
give a bow with an abnormally wide yellow band, since red and green
gɪv ʌ bow wɪθ æn æbnɔɹmʌlij wajd jəlow bænd sɪns ɹɛd ænd gɹijn
lights when mixed form yellow.
lajts whɛn mɪkt fɔɹm jəlow]

If the red of the second bow falls upon the green of the first, the result is
[ɪf ðʌ ɹɛd ʌv ðʌ sɛkɪn bow fɔls ʌpan ðʌ gɹijn ʌv ðʌ fɚst ðʌ ɹijsʌlt ɪs
to give a bow with an abnormally wide yellow band, since red and green
tuw gɪv ʌ bow wɪθ æn æbnɔɹmʌlij wajd jəlow bænd sɪns ɹɛd ænd gɹijn
lights when mixed form yellow. This is a very common type of bow, one
lajts whɛn mɪkt fɔɹm jəlow ð ɪs ɪs ʌ veɹij kamʌn tajp ʌv bow wʌn

showing mainly red and yellow with little or no green or blue.
ʃowɪŋ mejnlij ɹɛd ænd jəlow wɪθ lɪtl ɔɹ now gɹijn ɔɹ bluw]

Vocal Variety Sentences

Music may soothe or excite the mind and heart or even lull one to sleep.
[muwsk mej suθ ɔɹ ɛksət ðʌ majnd ænd haɹt ɔɹ ijvɪn lʌl wʌn tuw slijp]

Music may soothe or excite the mind and heart or even lull one to sleep.
[muwsk mej suθ ɔɹ ɛksət ðʌ majnd ænd haɹt ɔɹ ijvɪn lʌl wʌn tuw slijp]

Music may soothe or excite the mind and heart or even lull one to sleep.
[muwsk mej suθ ɔɹ ɛksət ðʌ majnd ænd haɹt ɔɹ ijvɪn lʌl wʌn tuw slijp]

The voice droned on and on as time passed intermittently until the lecture
[ðʌ vɔjs dɹʌnd an ænd an æs tajm pæst ɪntɚmɪtɪntlij ʌntɪl ðʌ lɛktɚ
was finally over and I was out of there like a shot.
wʌs fajnʌlij owvɚ ænd aj wʌs ʌwt ʌv ðɛɹ lajk ʌ ʃat]

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wʌs fajnʌlij owvɚ ænd aj wʌs ʌwt ʌv ðɛɹ lajk ʌ ʃat]

I just don't have time to stay now but I suppose I could give you a
[aj dʒʌst downt hæv tajm tuw stej nʌw bʌt aj sʌpows aj kʊd gɪv juw ʌ
minute but that's all.
mɪnɪt bʌt ðæts ɔl]

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minute but that's all.
mɪnɪt bʌt ðæts ɔl]

Don't make a sound tip toe quietly and maybe we won't wake anyone.
[downt mejk ʌ sʌwnd tɪptow kwajtlij ænd mejbij wij wownt wejk ɛnijwʌn]

Don't make a sound tip toe quietly and maybe we won't wake anyone.
[downt mejk ʌ sʌwnd tɪptow kwajtlij ænd mejbij wij wownt wejk ɛnijwʌn]

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Don't make a sound tip toe quietly and maybe we won't wake anyone.
[downt mejk ʌ sʌwnd tɪptow kwajtlij ænd mejbij wij wownt wejk ɛnijwʌn]

You don't mean to tell me that after all this time you still haven't finished
[juw downt mijn tuw tɛl mij ðæt æftɚ ɔl ðɪs tajm juw stɪl hævɪnt fɪnɪʃd
the first page of that report.
ðʌ fɚst pejg ʌv ðæt ɹijpɔɹt]

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the first page of that report.
ðʌ fɚst pejg ʌv ðæt ɹijpɔɹt]

Client: A.C.

Background Information: A.C. presents with mixed (spastic and flaccid) dysarthria. Her vocal characteristics consist of moderate to severe hypernasality, monotone, abnormal variation in pitch (low strangled sounding), severe tremulous tone with phonation breaks, severe dysphonia (loss of voice), and poor rhythm.

Data:

[k] Words and Sentences

<yawn>cat cat the cat wants to go out wants to
[g/kæt] [kæt] [ðʌ kæt wʌnts tuw gow ʌwt] [wʌnts tuw]
the cat wants to go out
[ðʌ kæt wʌnts tuw gow ʌwt]
cake I will bake a cake
[g/kejk] [aj wɪl bejk ʌ kejk]
I will bake bake make
[aj wɪl bejk] [bejk] [mejk]
bake I will bake a cake
[bejk] [aj wɪl bejk ʌ kejk]
coal put the coal on the fire fire
[kowl] [pʊt ðʌ kowl ʌn ðʌ fajɚ] [fajɚ]
cob give the cob to the animals give the
[kab] [gɪv ðʌ kab tuw ðʌ ænɪməls] [gɪv ðʌ]
give the cob to the animals cob cob cup cop cob
[gɪv ðʌ kab tuw ðʌ ænɪməls] [kab] [kab][kʌp] [kap][kab]
have some corn have some corn <yawn> have some corn
[hæv sʌm koɹn] [hæv sʌm koɹn] [hæv sʌm koɹn]
have some corn have some corn
[hæv sʌm koɹn] [hæv sʌm koɹn]
Will you have some corn? Will you have some corn?
[wɪl juw hæv sʌm koɹn] [wɪl juw hæv sʌm koɹn]
acorn acorn put the acorn on the pumpkin pumpkin
[ejkoɹn] [ejkoɹn] [pʊt ðʌ ejkoɹn ʌn ðʌ pʌmkɪn] [b/pʌmkɪn]
<yawn>on the pumpkin put the acorn on the pumpkin
[ʌn ðʌ pʌmkɪn] [pʊt ðʌ ejkoɹn ʌn ðʌ pʌmkɪn]
became I became a queen I became a queen
[bijkejm] [aj bijkejm ʌ kwijn] [aj bijkejm ʌ kwijn]
because I took the corn because I wanted it
[bijkʌz] [aj tʊk ðʌ koɹn bijkʌz aj wantɛd ɪt]
I took the corn I took the corn because I wanted it
[aj tʊk ðʌ koɹn] [aj tʊk ðʌ koɹn bijkʌz aj wantɛd ɪt]

I took the corn becuse I wanted it
[aj tʊk ðʌ kɔɹn bijkʌz aj wantɛd ɪt]
bookcase put the book in the bookcase
[bʊk kejs] [pʊt ðʌ bʊk ɪn ðʌ bʊk kejs]
making making I am making a pie apple
[mejkɪŋ] [mejkɪŋ] [aj æm mejkɪŋ ʌ paj] [æpəl]
second I am the second one
[sɛkʌnd] [aj æm ðʌ sɛkʌnd wʌn]
hike let's go for a hike
[hajk] [lɛts gow fɔɹ ʌ hajk]
cheek touch the touch the cheek touch touch the cheek
[ʧijk] [d/tʌʧ ðʌ] [tʌʧ ðʌ ʧijk] [tʌʧ] [tʌʧ ðʌ ʧijk]
bike bike Dick rode on the bike bike bike
[m,n/bajk] [m,n/bajk] [d ɪk ɹowd ʌn ðʌ bajk] [bajk] [bajk]
Dick rode on the bike Dick Dick Nick Mick tick tick Dick
[d ɪk ɹowd ʌn ðʌ bajk] [d ɪk] [d ɪk] [nɪk] [mɪk] [kɪk][tɪk] [d ɪk]
pick I will pick you I will pick you
[p ɪk] [aj wɪl pɪk juw] [aj wɪl pɪk juw]
sock hang up the sock hang up the sock
[sak] [hej ŋ ʌp ðʌ sak] [hejŋ ʌp ðʌ sak]
hang up the<yawn> hang up the sock
[hej ŋ ʌp ðʌ] [hej ŋ ʌp ðʌ sak]
lake lake let's go to the lake
[lejk] [lejk] [lɛts gow tuw ðʌ lejk]
cabinet put the ball in the cabinet
[kæbɪnɛt] [pʊt ðʌ bɔl ɪn ðʌ kæbɪnɛt]
carnival let's go to the carnival
[kaɹnɪvəl] [lɛts gow tuw ðʌ kaɹnɪvəl]
Kentucky Kentucky is a long way
[kɛntʌkij] [kɛntʌkij ɪs ʌ lɔŋ wej]
book keeper book keeper book keeper the book keeper will do it
[bʊk kijpɚ] [bʊk kijpɚ] [bʊk kijpɚ] [ðʌ bʊk kijpɚ wɪl duw ɪt]
will do it will do it will will will do it
[wɪl duw ɪt] [wɪl duw ɪt] [wɪl] [wɪl] [wɪl duw ɪt]
economy economy economy the economy is run down
[ijkʌnowmij] [ijkʌnowmij] [ijkʌnowmij] [ðʌ ijkʌnowmij ɪs ɹən dʌwn]
the economy is run down
[ðʌ ʌkʌnowmij ɪs ɹən dʌwn]
America America is a free country
[ʌmejɹkə] [ʌmejɹkə ɪs ʌ fɹij kʌntɹij]
arithmetic arithmetic do do your arithmetic
[ʌɹɪθmʌtɪk] [ʌɹɪθmʌtɪk] [duw duw jɔɹ ʌɹɪθmʌtɪk]

201 overlook over look overlook overlook
202 [owvɚlʊk] [owvɚlʊk] [owvɚlʊk] [owvɚlʊk]
203 let's go to the overlook
204 [lɛts gow tuw ðʌ owvɚlʊk]
205 epidemic epidemic there is an epidemic
206 [ɛpʌdɛmɪk] [ɛpʌdɛmɪk] [ðeɹ ɪs æn ɛpʌdɛmɪk]
207 there is an epidemic of chicken poxes of chicken poxes
208 [ðeɹ ɪs æn ɛpʌdɛmɪk ʌv ʧɪkɛn paks] [ʌv ʧɪkɛn paks]
209 there is an epidemic of chicken poxes
210 [ðeɹ ɪs æn ɛpʌdɛmɪk ʌv ʧɪkɛn paks]

[w] Words, Phrases, and Sentences

211 win can win I know I can win
212 [wɪn] [kæn wɪn] [aj now aj kæn wɪn]
213 way way new way she drove a new way
214 [wej] [wej] [nuw wej] [ʃij dɹowv ʌ nuw wej]
215 wood made of wood the box is made of wood
216 [wʊd] [mæd ʌv wʊd] [ðʌ baks ɪs mæd ʌv wʊd]
217 the box <yawn>the box is made of wood
218 [ðʌ baks] [ðʌ baks ɪs mæd ʌv wʊd]
219 wine drink wine I like to drink red wine
220 [wajn] [dɹɪnk wajn] [aj lajk tuw dɹɪnk ɹɛd wajn]
221 walk for a walk lets go for a walk
222 [wɔk] [fɔɹ ʌ wɔk] [lɛts gow fɔɹ ʌ wɔk]
223 woe feel woe I feel woe
224 [wow] [fijl wow] [aj fijl wow]

Client: L.C.

Background Information: L.C. presents with hypokinetic dysarthria. Her vocal characteristics consists of breathiness, reduced pitch range, poor pitch inflection, reduced ability to sustain phonation, poor vocal intensity, poor synchronization of exhalation and speech production.

Data:

Distinguish [j] from [w]

225 yet-wet yacht-watt yale-whale yen-when you'd-wooed
226 [jɛt-wɛt] [jʌt-wʌt] [jæl-wæl] [jɛn-wɛn] [juwd-wuwd]
227 yaks-wax yaks yes-wes year-wier yawl-wall
228 [jaks-wæk] [jæks] [jijs-wɛs] [jiɹ-wiɹ] [jɔl-wɔl]
229 yell-well yield-wield ye-we
230 [jijl-wɛl] [jijld-wijld] [jij-wij]

[w] Words

231 walk want was
232 [wɔk] [want] [wʌs]

[w] Words in Sentences

233 I went for a walk. I want to go to the dance. I was not there.
234 [aj wɛnt fɔɹ ʌ wɔk] [aj want tuw gow tuw ðʌ dæns] [aj wʌs nat ðeɹ]
235 I like warm water. I like warm water.
236 [aj lajk wɔɹm wɔtɚ] [aj lajk wɔɹm wɔtɚ]
237 Which is the way to go? Which is the way to go?
238 [wɪʧ ɪs ðʌ wej tuw gow] [wɪʧ ɪs ðʌ wej tuw gow]
239 We are not going? It is well to do well.
240 [wij aɹ nat gowŋ] [ɪt ɪs wɛl tuw duw wɛl]
241 We went to the store. We were there.
242 [wij wɛnt tuw ðʌ stɔɹ] [wij wɚ ðeɹ]
243 Wash the car. Wax the car. Wash the car. Wax the car.
244 [waʃ ðʌ kaɹ] [wæk ðʌ kaɹ] [waʃ ðʌ kaɹ] [wæk ðʌ kaɹ]
245 Weed the garden. The wind was to hard. Is the wind blowing?
246 [wijd ðʌ gʌɹdɛn] [ðʌ wɪnd wʌs tuw hʌɹd] [ɪs ðʌ wɪnd blowŋ]
247 Do you wish to go to the store?
248 [dow juw wɪʃ tuw gow tuw ðʌ stɔɹ]
249 With what do you want to do that with? I won the prize.
250 [wɪθ wʌt dow juw wʌnt tuw dow ðæt wɪθ] [aj wʌn ðʌ pɹajz]
251 The word was wrong. Do not work so hard.
252 [ðʌ wɚd wʌs wɹʌŋ] [duw nʌt wɚk sow hʌɹd]

[w] Clusters

twleve twice twig twin twist
[twʌlv][twajs] [twɪg] [twɪn] [twɪst]
quest quick quiet quell
[kwɛst][kwɪk] [kwajt] [kwɪl]
sweep swim swell swear swan
[swijp][swɪm] [swʌl] [sweɹ] [swan]
squeak squat square squint squall
[skwijk][skwat][skweɹ][skwɪnt][skwɔl]

[w] Sentences

Willie is going to wash the windows. wash the windows.
[wɪlij..wɪlij ɪs gowŋ tuw wæʃ ðʌ wɪndows... wæʃ ðʌ wɪndows]
Willie Willie is going to wash the windows.
[wɪlij..wɪlij ɪs gowŋ tuw wæʃ ðʌ wɪndows]
Willie is going to wash the windows.
[wɪlij..wɪlij ɪs gowŋ tuw wæʃ ðʌ wɪndows]
Willie is going to wash the windows.
[wɪlij..wɪlij ɪs gowŋ tuw wæʃ ðʌ wɪndows]
Willie is going to wash the windows.
[wɪlij..wɪlij ɪs gowŋ tuw wæʃ ðʌ wɪndows]
Willie is going to wash the windows.
[wɪlij..wɪlij ɪs gowŋ tuw wæʃ ðʌ wɪndows]

I wish Mary would wake up. I wish Mary would wake up.
[aj wɪʃ meɹ wʊd wejk ʌp] [aj wɪʃ meɹ wʊd wejk ʌp]
I wish Mary would wake up. I wish Mary would wake up.
[aj wɪʃ meɹ wʊd wejk ʌp][aj wɪʃ meɹ wʊd wejk ʌp]
I wish Mary would wake up.
[aj wɪʃ meɹ wʊd wejk ʌp]

Do not walk in the woods; they are wet. Do not walk in the woods; they are
[duw nʌt wɔk ɪn ðʌ wʊds; ðej aɹ wɛt][duw nʌt wɔk ɪn ðʌ wʊds; ðej aɹ
wet. Do not walk in the woods; they are wet. Do not walk in the woods; they
wɛt] [duw nʌt wɔk ɪn ðʌ wʊds; ðej aɹ wɛt][duw nʌt wɔk ɪn ðʌ wʊds; ðej
are wet.
aɹ wɛt]

We are going away this winter. We are going away this winter. We are really
[wij aɹ gowɪŋ ʌwej ðɪs wɪntɚ] [wij aɹ gowɪŋ ʌwej ðɪs wɪntɚ] [wij aɹ ɹijlij
going away this winter. We are going away this winter. We are going away this
gowɪŋ ʌwej ðɪs wɪntɚ] [wij aɹ gowɪŋ ʌwej ðɪs wɪntɚ] [wij aɹ gowɪŋ ʌwej ðɪs

289 winter.
290 wɪntɚ]

291 We can win without a reward. We can win without a reward.
292 [wij kæn wɪn wɪθʌwt ʌ ɹijwɔɹd] [wij kæn wɪn wɪθʌwt ʌ ɹijwɔɹd]

293 I wish he would watch his words. I wish he would watch his words.
294 [aj wɪʃ hij wʊd wʌʧ hɪs wɚds] [aj wɪʃ hij wʊd wʌʧ hɪs wɚds]

295 He awakened at once and went to the well for water. He awakened at once and
296 [hij wejkɪnd æt wʌns ænd wɛnt tuw ðʌ wɛl fɔɹ wɔtɚ] [hij wejkɪnd æt wʌns ænd
297 went to the well for water. He awakened at once and went to the well for water
298 wɛnt tuw ðʌ wɛl fɔɹ wɔtɚ] [hij wejkɪnd æt wʌns ænd wɛnt tuw ðʌ wɛl fɔɹ wɔtɚ
299 water
300 wɔtɚ]

301 Wishing for wealth is one way to waste time unwisely. Wishing for wealth
302 [wɪʃɪŋ fɔɹ wɛlθ ɪs wʌn wej tuw wejst tajm ʌnwajslij] [wɪʃɪŋ fɔɹ wɛlθ
303 wishing for wealth is one way to waste time unwisely. Wishing your wishing for
304 wɪʃɪŋ fɔɹ wɛlθ ɪs wʌn wej tuw wejst tajm ʌnwajslij] [wɪʃɪŋ jɔɹ wɪʃɪŋ fɔɹ
305 wealth is one way to waste time unwisely. Wishing for wealth is one way to
306 wɛlθ ɪs wʌn wej tuw wejst tajm ʌnwajslij] [wɪʃɪŋ fɔɹ wɛlθ ɪs wʌn wej tuw
307 waste time unwisely.
308 wejst tajm ʌnwajslij]

Distinguish [ ] from [h]

309	eat-heat	ate-hate	ill-hill	it-hit	eel-heel	ease-he's
310	[ijt-hijt]	[ejt-hejt]	[ɪl-hɪl]	[ɪt-hɪt]	[ijl-hijl]	[ijs-hijs]
311	ear-hear	ear-hear	ear-hear	air-hair	air-hair	ire-hire
312	[iɹ-hiɹ]	[iɹ-hiɹ]	[iɹ-hiɹ]	[eɹ-heɹ]	[eɹ-heɹ]	[ajɹ-hajɹ]
313	owl-howl	owl-howl	am-ham	odd-hod		
314	[awl-hawl]	[awl-hawl]	[æm-hæm]	[ʌd-hʌd]		

[l] Words, Phrases, and Sentences

315 Love, in love, Larry's in love. Love, in love, Larry's in love.
316 [lʌv ɪn lʌv leɹijs ɪn lʌv] [lʌv ɪn lʌv leɹijs ɪn lʌv]
317 Laugh, make me laugh, Larry can make me laugh.
318 [læf mejk mij læf leɹijs kæn mejk mij læf]
319 League, little league, league, little league, she plays in little league.
320 [lijg lɪtəl lijg lijg lɪtəl lijg ʃij plejs ɪn lɪtəl lijg]
321 Loose, feels loose, my pants feel loose.
322 [luws fijls luws maj pænts fijl luws]

323 Light, light sweater, take a light sweater.
324 [lʌt lʌt swɛtɚ tejk ʌ lʌt swɛtɚ]
325 Light, light sweater, take a light sweater.
326 [lʌt lʌt swɛtɚ tejk ʌ lʌt swɛtɚ]
327 Lap, on my lap, the cat is on my lap.
328 [læp ʌn maj læp ðʌ kæt ɪs ʌn maj læp]

Questions vs. Sentences

329 How how big is the lion?/ How big is the lion?/ The lion is huge._
330 [hʌw hʌw bɪg ɪs ðʌ lajən][hʌw bɪg ɪs ðʌ lajən][ðʌ lajən ɪs huwg]
331 Let's look at the lion.\ How big is the lion?/ How big is the lion?/
332 [lɛts lʊk æt ðʌ lajən][hʌw bɪg ɪs ðʌ lajən][hʌw bɪg ɪs ðʌ lajən]
333 That lion is huge._ Let's look at that lion.\
334 [ðʌ lajən ɪs huwg][lɛts lʊk æt ðʌ lajən]

335 Do you know a lawyer?/ I am a lawyer.\ I don't know a lawyer.\
336 [duw juw now ʌ lɔjɚ] [aj æm ʌ lɔjɚ] [aj downt now ʌ lɔjɚ]
337 Do you know a lawyer?/ Do you know a lawyer?/ I am a lawyer.\
338 [duw juw now ʌ lɔjɚ] [duw juw now ʌ lɔjɚ] [aj æm ʌ lɔjɚ]
339 I don't know a lawyer.\
340 [aj downt now ʌ lɔjɚ]

341 How much is lumber?\ How much is lumber?/ Lumber is very expensive.\
342 [haw mʌʧ ɪs lʌmbɚ] [haw mʌʧ ɪs lʌmbɚ] [lʌmbɚ ɪs veɹ ɛkspɪnsɪv]
343 I need a lot of lumber.\
344 [aj nijd ʌ lʌt ʌf lʌmbɚ]

345 Is that surface level?/ That surface is hardly level.\ We need a level surface.\
346 [ɪs ðæt sɚfɪs lɛvəl] [ðæt sɚfɪs ɪs haɹdij lɛvəl] [wij nijd ʌ lɛvəl sɚfɪs]
347 We need a level surface.\ We need a level surface.\
348 [wij nijd ʌ lɛvəl sɚfɪs] [wij nijd ʌ lɛvəl sɚfɪs]

349 Why are you so lazy? / I am not lazy.\ I feel lazy today.\
350 [waj aɹ juw sow lejzij] [aj æm nʌt lejzij] [aj fijl lejzij tuwdej]
351 Why are you so lazy?/ I am not lazy.\ I feel lazy today.\
352 [waj aɹ juw sow lejzij] [aj æm nʌt lejzij] [aj fijl lejzij tuwdej]

353 When do you get lonely?/ I am lonely every Friday night.\
354 [whɛn duw juw gɛt lownlij] [aj æm lownlij ɛvɚij fɹajdej najət]
355 I get lonely ever now and then.\ When do you get lonely?/
356 [aj gɛt lownlij ɛvɚij naw ænd ðɛn] [whɛn duw juw gɛt lownlij]

I am lonely every Friday night.\ I am lonely every Friday night.\
[aj æm lownlij ɛvɚij fɹajdej najət] [aj æm lownlij ɛvɚij fɹajdej najət]
I get lonely every now and then.\
[aj gɛt lownlij ɛvɚij naw ænd ðɛn]

Did you buy any liquor?/ I never buy liquor.\ Liz bought the liquor.\
[dɪd juw baj ɛnij lɪkɚ] [aj nɛvɚ baj lɪkɚ] [lɪz bɔt ðʌ lɪkɚ]

Can can you read the label?/ I can't read the label.\ The label says size twelve.\
[kæn kæn juw ɹijd ðʌ lejbəl] [ajkænt ɹ ijd ðʌ lejbəl] [ðʌ lejbəl sɛz sajz twɛlv]
Can you can you read the label?/ I can't read the label.\
[kæn juw kæn juw ɹijd ðʌ lejbəl] [aj kænt ɹ ijd ðʌ lejbəl]
The label says size twelve.\
[ðʌ lejbəl sɛz sajz twɛlv]

Vocal Variability

Music may soothe or excite the mind and heart or even lull one to sleep.
[muwsk mej suθ ɔɹ ɛksət ðʌ majnd ænd haɹt ɔɹ ijvɪn lʌl wʌn tuw slijp]

Music may soothe or excite the mind and heart .. mind and heart or even lull one
[muwsk mej suθ ɔɹ ɛksət ðʌ majnd ænd haɹt majnd ænd haɹt ɔɹ ijvɪn lʌl wʌn
to sleep.
tuw slijp]

Music may soothe or excite the mind and heart or even lull one to sleep.
[muwsk mej suθ ɔɹ ɛksət ðʌ majnd ænd haɹt ɔɹ ijvɪn lʌl wʌn tuw slijp]

Music may soothe or excite the mind and heart or even lull one to sleep.
[muwsk mej suθ ɔɹ ɛksət ðʌ majnd ænd haɹt ɔɹ ijvɪn lʌl wʌn tuw slijp]

Music.. music may soothe or excite the mind and heart or even lull one to sleep.
[muwsk muwsk mej suθ ɔɹ ɛksət ðʌ majnd ænd haɹt ɔɹ ijvɪn lʌl wʌn tuw slijp]

The voice droned on and on as time passed intermittently until the lecture was
[ðʌ vɔjs dɹʌnd an ænd an æs tajm pæst ɪntɚmɪtɪntlij ʌntɪl ðʌ lɛktɚ wʌs
finally over and I was out of there like a shot.
fajnʌlij owvɚ ænd aj wʌs ʌwt ʌv ðeɹ lajk ʌ ʃat]

The voice droned on and on as time passed intermittently until the lecture was
[ðʌ vɔjs dɹʌnd an ænd an æs tajm pæst ɪntɚmɪtɪntlij ʌntɪl ðʌ lɛktɚ wʌs
finally over and I was out of there like a shot.
fajnʌlij owvɚ ænd aj wʌs ʌwt ʌv ðeɹ lajk ʌ ʃat]

I just don't have time to stay now, but I suppose I could give you a
[aj dʒʌst downt hæv tajm tuw stej nʌw bʌt aj sʌpows aj kʊd gɪv juw ʌ
minute but that's all. I just don't know
mɪnɪt bʌt ðæts ɔl] [aj dʒʌst downt now]

I just don't have time to stay now, but I suppose I could give you a
[aj dʒʌst downt hæv tajm tuw stej nʌw bʌt aj sʌpows aj kʊd gɪv juw ʌ
minute but that's all.
mɪnɪt bʌt ðæts ɔl]

Don't make a sound tiptoe quietly and maybe we won't wake anyone
[downt mejk ʌ sʌwnd tɪptow kwajtlij ænd mejbij wij wownt wejk ɛnijwʌn
up.
ʌp]

You don't mean to tell me that after all this time you still haven't finished
[juw downt mijn tuw tɛl mij ðæt æftɚ ɔl ðɪs tajm juw stɪl hævɪnt fɪnɪʃd
the first page of that report.
ðʌ fɚst pejg ʌv ðæt ɹijpɔɹt]

You don't mean to tell me that after all this time you still haven't finished
[juw downt mijn tuw tɛl mij ðæt æftɚ ɔl ðɪs tajm juw stɪl hævɪnt fɪnɪʃd
the first page of that report.
ðʌ fɚst pejg ʌv ðæt ɹijpɔɹt]

You don't mean to tell me that after all this time you still haven't finished
[juw downt mijn tuw tɛl mij ðæt æftɚ ɔl ðɪs tajm juw stɪl hævɪnt fɪnɪʃd
the first page of that report.
ðʌ fɚst pejg ʌv ðæt ɹijpɔɹt]

Appendix E
Data on Rhythm

The transcribed data below illustrates the stress patterns for E.C. and A.C. The analysis of this data will provide information on the client's rhythm (see sections 4.0.1.6 and 4.1.1.6). The underlined words possess too much stress. (Function words such as 'the', 'a', and 'I', etc. are usually unstressed in conversation.)

Client: E.C.

Data:

Rainbow Passage

303 Whén the súnlìght stríkes ráindròps in the áir, théy áct líke a whíte líght and fórm a
304 [whɛn <u>ðʌ</u> sʌnlajt stɹajks ɹejndɹʌps ɪn <u>ðʌ</u> eɹ ðej ækt lajk ʌ wajt lajt <u>ænd</u> fɔɹm ʌ
305 ráinbòw. The ráinbòw is a dívision of whíte líght into mány béautifùl cólòrs.
306 ɹejnbow <u>ðʌ</u> ɹejnbow ɪs ʌ d ɪv ɪʒʌn ʌv wajt lajt <u>ɪntuw</u> mʌnij bjuwtɪful kʌlɚs
307 Thése táke the shápe of a lóng róund árch, with its páth ríght abóve and its
308 ðijz tejk <u>ðʌ</u> ʃejp ʌv ʌ lɔŋ ɹʌwnd ʌɹʧ wɪθ ɪts pæθ ɹʌjt ʌbʌv <u>ænd</u> ɪts
309 twó énds appárentlỳ bèyónd the hòrízòn.
310 tjuw ɛndz ʌpejɹɪntlij bijʌnd <u>ðʌ</u> hɔɹajzʌn]

Vocal Variety Sentences

9 Músic máy sóothe or éxcite the mínd and héart or éven lúll óne to sléep.
10 [muwsk mej suθ <u>ɔɹ</u> ɛksət <u>ðʌ</u> majnd <u>ænd</u> haɹt <u>ɔɹ</u> ijvɪn lʌl wʌn <u>tuw</u> slijp]

11 The vóice dróned ón and ón as tíme pássed íntermíttentlỳ ùntíl the léctùre
12 [<u>ðʌ</u> vɔjs dɹʌnd an <u>ænd</u> an <u>æs</u> tajm pæst ɪntɚmɪtɪntlij ʌntɪl <u>ðʌ</u> lɛktɚ
13 was fínallỳ óver and Í was óut of thére líke a shót.
14 wʌs fajnʌlij owvɚ <u>ænd</u> aj wʌs ʌwt ʌv ðeɹ lajk ʌ ʃat]

15 Í júst dón't háve tíme to stáy nów but Í sùppóse Í cóuld gíve yóu a
16 [aj ʤʌst downt hæv tajm <u>tuw</u> stej nʌw <u>bʌt</u> aj sʌpows aj kʊd gɪv juw ʌ
17 mínute but thát's áll.
18 mɪnɪt <u>bʌt</u> ðæts ɔl]

19 Dón't máke a sóund típ tòe quíetlỳ and máybè wé wón't wáke ányòne.
20 [downt mejk ʌ sʌwnd tɪptow kwajtlij <u>ænd</u> mejbij wij wownt wejk ɛnijwʌn]

21 Yóu dón't méan to téll me that áfter áll this tíme yóu stíll hávèn't fínìshed
22 [juw downt mijn <u>tuw</u> tɛl mij <u>ðæt</u> æftɚ ɔl ðɪs tajm juw stɪl hævɪnt fɪnɪʃd
23 the fírst páge of thát répòrt.
24 <u>ðʌ</u> fɚst pejg ʌv ðæt ɹijpɔɹt]

Client: A.C.

Data:

[k] Words and Sentences

25 báke I will báke a cáke
26 [bejk] [aj wɪl bejk ʌ kejk]
27 cóal pút the cóal on the fíre fíre
28 [kowl] [pʊt ðʌ kowl ʌn ðʌ fajɚ] [fajɚ]
29 bècáme I bècáme a quéen I bècáme a quéen
30 [bijkejm] [aj bijkejm ʌ kwijn] [aj bijkejm ʌ kwijn]
31 bècáuse I tóok the córn bècáuse I wánted it
32 [bijkʌz] [aj tʊk ðʌ kɔɹn bijkʌz aj wantɛd ɪt]
33 cábinèt pút the báll in the cábinèt
34 [kæbɪnɛt] [pʊt ðʌ bɔl ɪn ðʌ kæbɪnɛt]
35 cárnival lét's gó to the cárnival
36 [kaɹnɪvəl] [lɛts gow tuw ðʌ kaɹnɪvəl]
37 Kèntúckỳ Kèntúckỳ is a lóng wáy
38 [kɛntʌkij] [kɛntʌkij ɪs ʌ lɔŋ wej]

[w] Words, Phrases, and Sentences

39 wín cán wín I knów I cán wín
40 [wɪn] [kæn wɪn] [aj now aj kæn wɪn]
41 wáy wáy néw wáy she dróve a néw wáy
42 [wej] [wej] [nuw wej] [ʃij dɹowv ʌ nuw wej]
43 wóod máde of wóod the bóx is máde of wóod
44 [wʊd] [mæd ʌf wʊd] [ðʌ baks ɪs mæd ʌv wʊd]
45 the bóx <yawn>the bóx is máde of wóod
46 [ðʌ baks] [ðʌ baks ɪs mæd ʌv wʊd]
47 wíne drínk wíne I líke to drínk réd wíne
48 [wajn] [dɹɪnk wajn] [aj lajk tuw dɹɪnk ɹɛd wajn]
49 wálk for a wálk léts gò for a wálk
50 [wɔk] [fɔɹ ʌ wɔk] [lɛts gow fɔɹ ʌ wɔk]
51 wóe féel wóe I féel wóe
52 [wow] [fijl wow] [aj fijl wow]